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Medicine Track
Abstracts and Presentations



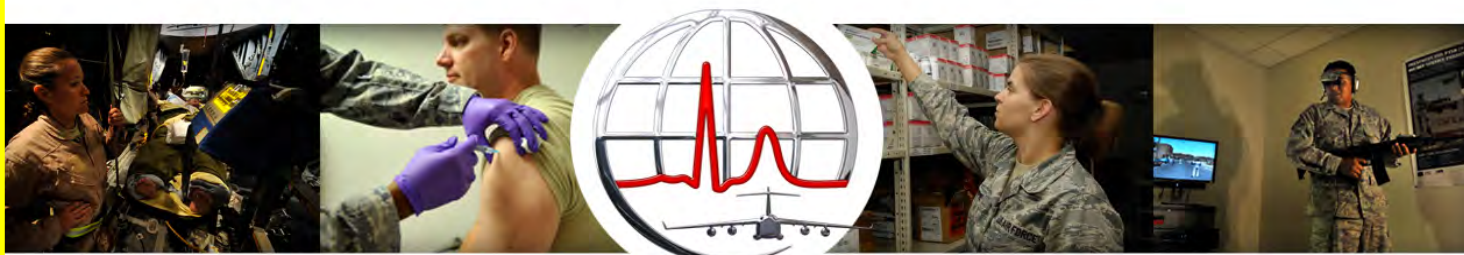
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Proceedings of the 2011 AFMS Medical Research Symposium Volume 2. Enroute Care Track Abstracts and Presentations

Edited by: Ms. Velda Johnson



Held
2-4 August 2011
at the
Gaylord National Resort Hotel and Convention Center
201 Waterfront Street
National Harbor, MD 20745



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Proceedings of the 2011 AFMS Medical Research Symposium Introduction

The U.S. Air Force Medical Service presented the sixth annual Air Force Medical Research Symposium coordinated by the Air Force Medical Support Agency's Research and Development Division (AFMSA/SGRS). The symposium was held on 2-4 August 2011 in the Washington DC area at the Gaylord National Resort Hotel and Convention Center in National Harbor, MD. The symposium featured two half-days of plenary sessions, one and a half days of scientific presentations, and a poster session.

The symposium was organized into several tracks to include Enroute Care, Force Health Protection, Healthcare Informatics, Operational Medicine (In-Garrison Care), and Psychological Health/Traumatic Brain Injury, as follows:

- The Enroute Care Track addressed science and technology targeted at the continuum of care during transport from point of injury to definitive care including, but not limited to: Casevac, Medivac; Aeromedical Evacuation; Critical Care Air Transport; and Patient Staging. Further areas addressed included: patient stabilization; patient preparation for movement; impact of in-transit environment on patient and AE crew physiology; human factors concerns for AE crew or patient population; AE/medical personnel training; infectious disease/control; burn management; pain management; resuscitation; lifesaving interventions; and nutrition research in the enroute care environment.
- The Force Health Protection Track focused on prevention of injury and illness and the early recognition or detection of emerging threats for in-garrison or deployed operations. Topics of interest include research in bio-surveillance, infectious disease, emerging threats (pandemic response), protective countermeasures, disaster response/consequence management, toxicology/health risks (e.g., particulates nanomaterials, radiation, etc.), monitoring disease trends, other areas of preventive medicine, public and environmental health relevant to the military workforce.
- The Healthcare Informatics Track focused on the use of innovative information management & technology solutions that enhance healthcare delivery at any point of the full spectrum of patient care to include medical simulation and training.
- The Operational Medicine (In-Garrison Care) Track focused on care delivered in the outpatient or inpatient in-garrison setting and on enhancing the performance of airman in challenging operational and expeditionary environments.
- The Psychological Health/Traumatic Brain Injury Track addressed topics pertaining to screening, diagnosis, and treatment of TBI and/or Psychological Health in the military community. Specific focus areas within Psychological Health included depression, substance use disorders, family functioning, and suicide prevention. Topics of special interest included field-deployable diagnostic tests for mild TBI (concussion), blast modeling, large epidemiologic studies of Psychological Health and TBI, and strategies for translating research into practice.

These proceedings are organized into five volumes, as follows:

- Volume 1. This volume is a general overview of the entire 2011 Air Force Medical Research Symposium and includes abstracts of all the oral presentations and posters. First presented is the symposium's opening plenary session, followed by the abstracts from the four technical tracks, and then the closing plenary session. The abstracts associated with the poster session are in the last section of these proceedings. The agenda for the overall symposium is in Appendix A, attendees are listed in Appendix B, and continuing education information is in Appendix C of this volume. Appendices D-J are copies of presentation slides from the plenary sessions.
- Volume 2. This volume contains abstracts and presentation slides for the Enroute Care and Expeditionary Medicine Track.
- Volume 3. This volume contains abstracts and presentation slides for the Force Health Protection Track.
- Volume 4. This volume contains abstracts and presentation slides for the Healthcare Informatics Track.
- Volume 5. This volume contains abstracts and presentation slides for the Operational Medicine (In-Garrison Care) Track.
- Volume 6. This volume contains abstracts and presentation slides for the Psychological Health/Traumatic Brain Injury Track.

Effects of Aeromedical Evacuation on Intracranial Pressure

711 HPW/USAFSAM-ETS

Mr. Richard Branson

PURPOSE: Early evacuation of casualties has been a hallmark of the current conflict, with traumatic brain injury (TBI) being the defining injury. The effects of aeromedical evacuation (AE) on intracranial pressure (ICP) have not been studied in humans. **METHODS:** ICP and blood pressure were both continuously recorded during AE from in-theater hospitals to Germany in six patients with TBI. All patients were mechanically ventilated and had an intraventricular catheter and arterial lines. A recorder with airworthiness approval was connected to the output of a standard pressure transducer. Data were collected every second. The recorder also measured X,Y, and Z via an integral accelerometer. **RESULTS:** Six patients had complete take-off to landing data collected. In four of six patients there were sustained increases in ICP associated with take-off and/or during the 6- to 8-hr flight. These increases were often >50% from baseline and were sustained for >1 hr. However, no patient suffered sustained ICP increases >20 mmHg. All data were collected without identifiers and no attempt was made to link the collected data to patient information from medical records. **CONCLUSIONS:** This study demonstrates that observational data from current standard of care environments can be invaluable in identifying potential problems and solutions. Routine AE is associated with increases in ICP owing to environmental and injury factors. Monitoring during AE is possible without altering patient care.

Effects of Aeromedical Evacuation on Intracranial Pressure

*Rich Branson, MSc, RRT
Professor of Surgery*

Sponsored by the 711th HPW

Background

- Traumatic brain injury (TBI) is a signature injury of the war in Iraq and Afghanistan.
- Early aeromedical evacuation to definitive care represents a paradigm shift in the care of these TBI patients.

Methods

- Intracranial pressure (ICP) monitoring via an intraventricular catheter requires a pressure transducer and connection to a physiologic monitor.
- We used a modified pressure transducer with two signal outputs (FloTrac, Edwards) to monitor ICP clinically and record changes in ICP and blood pressure.

Data Logger



Transducer Connection



Regulatory Review

- Informed consent not possible.
- Determination of "not clinical research" by UC and Wright-Patterson Air Force Base Institutional Review Boards.
- No patient data or PHI is collected.
- This process limits the interpretation of the data.
- De-identified data set for understanding the current state of care.

Methods

- Inclusion criteria
 - Traumatic brain injury
 - Inferior vena cava (IVC) for ICP monitoring/management
 - > 18 yr old
- Exclusion criteria
 - Personnel not available for setup



Methods

- IVC and arterial catheter connected (if available) to monitoring system.
- Data logger contains an accelerometer (xyz).
- xyz allows determination of take-off and landing as well as other position changes.



Results

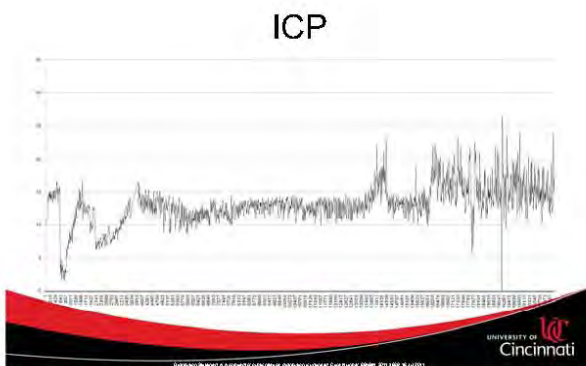
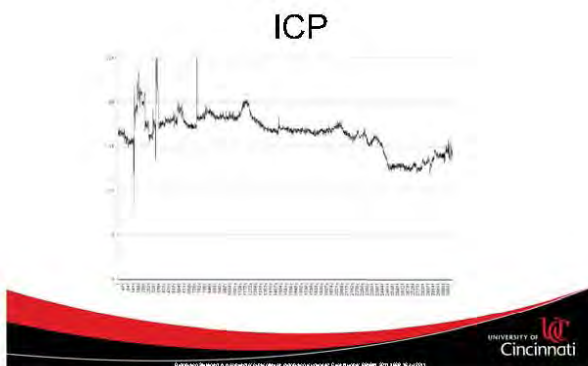
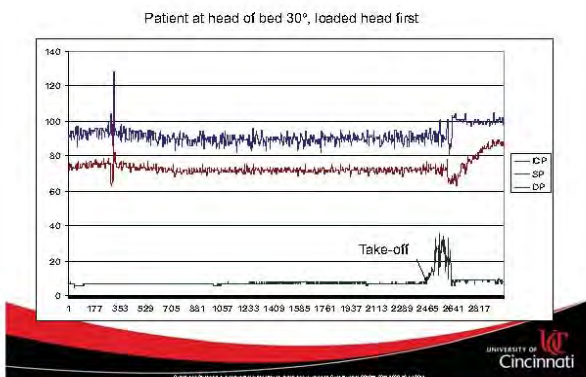
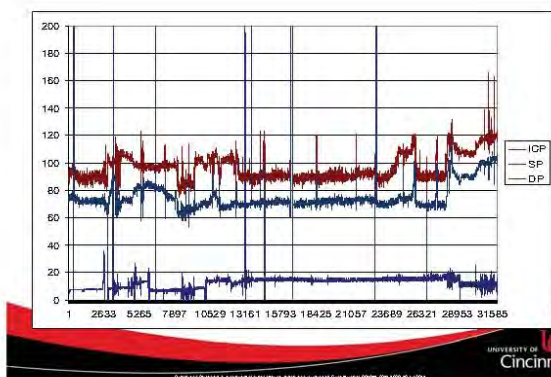
- Thirteen patients were identified.
- Six patients had successful monitoring of the entire transport.
- Data collection failures – battery exhaustion, disconnected devices, IVC set to drain.
- Monitoring did not impact patient care or decision making.

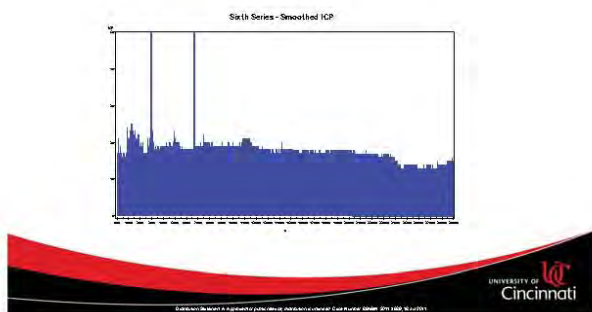
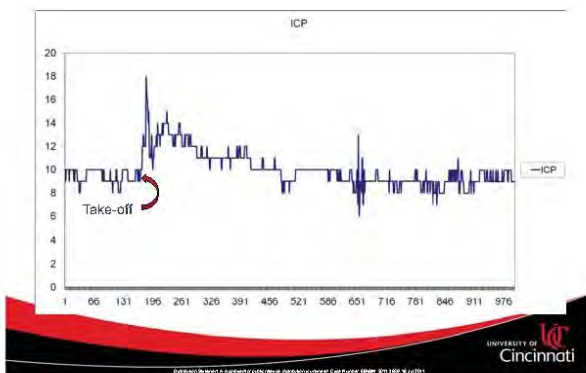
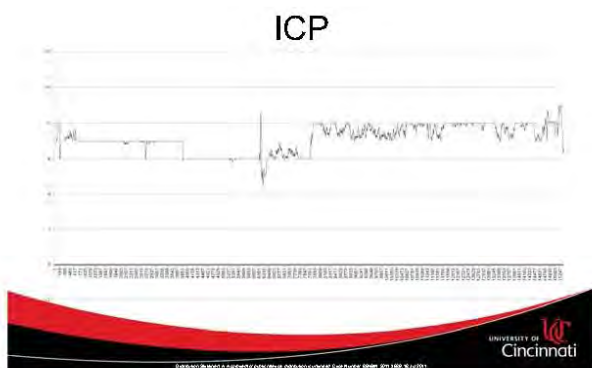


Results

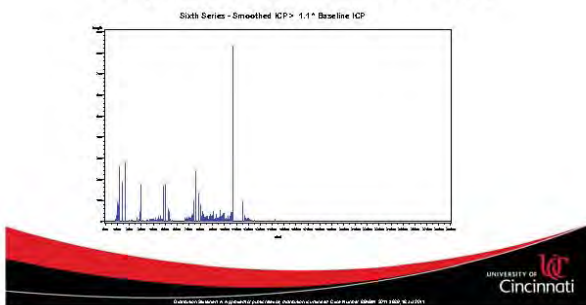
- No patient had sustained ICP > 20 mmHg during transport.
- A number of patients had increases in ICP during take-off and landing.
- During transport, ICP was commonly > 50% of baseline.
- Frequent ICP spikes occurred during transport.



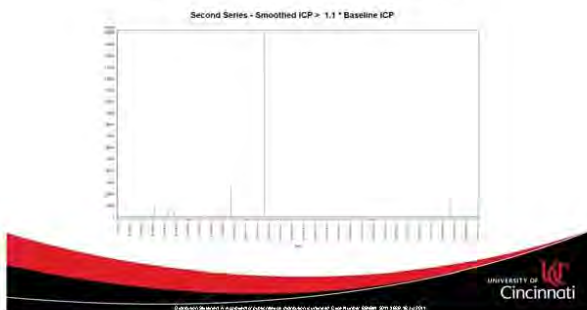




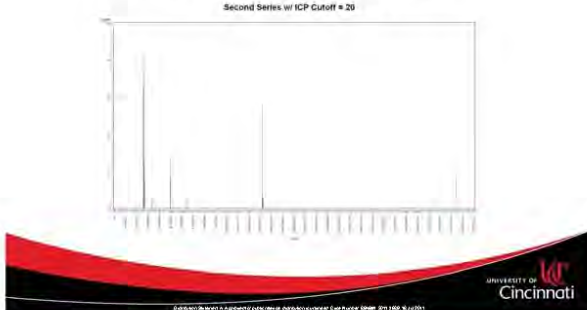
Each Episode > 110% of Baseline
Height of the Line Is Duration (s)



ICP > 110% of Baseline (s)



ICP > 20 mmHg (s)



Way Forward

- Continue data collection.
- Review regulatory requirements with goal of protecting subjects while allowing more complete data collection.
- Require new Patient Movement Item to collect data continuously for review.



Acknowledgments

- This work would be impossible without
 - Chris Blakeman, Dario Rodriguez, Carolina Rodriguez, Dennis Hanseman – UC
 - Rick Pettys, David Headley – Sparxx Engineering
 - Men and women of the U.S. Armed Forces




Prolonged Hypobaria During Aeromedical Evacuation and the Effects on Traumatic Brain Injury

711 HPW/USAFSAM-ETS

Dr. Gary Fiskum

BACKGROUND: Warfighters evacuated from combat theaters are exposed to decreased atmospheric pressure (hypobaria) during air transport. The focus of this project is to characterize the effects of hypobaria associated with aeromedical evacuation (AE) on animals subjected to traumatic brain injury (TBI) and test for clinically translational neuroprotective interventions targeted at these conditions. **HYPOTHESIS:** We hypothesize that (1) low atmospheric pressure present at AE cruising altitudes worsens outcome after TBI, (2) the effects of prolonged hypobaria on outcome after TBI are dependent upon timing of transport, (3) these effects reflect neuroinflammatory and/or cerebral metabolic changes, and (4) the neurologic outcome after TBI and AE can be improved by interventions that target neuroinflammation and brain oxygenation. **STUDY DESIGN:** Animals will be exposed to prolonged hypobaria (6 hr at 0.75 ATA), beginning at different times after TBI (6, 24, or 72 hr), representing immediate evacuation, standard, or delayed AE after injury in theater. Additional groups of animals will be exposed to primary hypobaria and then prolonged secondary hypobaria, modeling AE from Europe to the U.S. Two clinically relevant TBI models will be examined: (1) contusion-induced moderate TBI using the rat lateral fluid percussion model and (2) mild, blast-induced hyperacceleration TBI in rats as a model for TBI in occupants of vehicles hit by improvised explosive devices. Comparisons of long-term histopathologic and behavioral outcomes for animals in these groups will provide data to suggest the optimum time for primary and secondary AE after TBI, as well as the impact of poly-ADP-ribose polymerase administration or hyperoxia on subsequent outcome.



**PROLONGED HYPOBARIA DURING
AEROMEDICAL EVACUATION
AND THE EFFECTS ON TRAUMATIC BRAIN
INJURY**

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DISCLOSURE

This research is supported by
USAF Cooperative Agreement
Contract FA8650-11-2-6142

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**TRAUMATIC BRAIN INJURY
A Major Warfighter Health Problem**

- Over 300,000 warfighter victims of TBI, caused mainly by blasts.
- Many victims are occupants within vehicles targeted by improvised explosive devices.
- These vehicles and occupants can be exposed to large G forces, exceeding several hundred Gs.
- In addition to head impact injuries, acceleration may play an important role in TBI associated with underbody blasts.
- Victims of moderate-severe TBI and polytrauma with mild TBI undergo aeromedical evacuation (AE) to Landstuhl and subsequently to the U.S.




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KNOWLEDGE GAPS

- Does AE worsen outcome after TBI?
- Is the negative impact of AE caused by hypobaria?
- Are different forms of TBI affected differently by hypobaria?
- Does hypobaria elevate intracranial pressure (ICP) and reduce brain oxygenation?
- Can time of AE optimize outcome?
- What level of inspired O₂ during hypobaria results in best outcome?
- Can outcome after TBI and hypobaria be improved by anti-inflammatory interventions?

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BACKGROUND

- Goodman et al., Hypobaric hypoxia exacerbates the neuroinflammatory response to traumatic brain injury. J Surg Res. 2011 Jan;165(1):30-7.
- Goodman et al., Traumatic brain injury and aeromedical evacuation: when is the brain fit to fly? J Surg Res. 2010 Dec;164(2):286-93. Epub 2009 Aug 26. Review.

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EXPERIMENTAL PARADIGM

- Subject adult male rats to TBI caused by either lateral fluid percussion (LFP) or underbody blast-induced hyperacceleration.
- Place in hypobaric chamber (0.75 atm) at different times after TBI and maintain for 6 h (initial AE) in the absence or presence of a subsequent 10-h period of hypobaria (secondary AE).
- Perform quantitative neurohistopathology and various behavioral outcome measurements at up to 30 days post-TBI.
- Collect serum for biomarker assays
- Compare outcomes among hypobaria groups (including sham exposure) and to sham-injured controls.
- Test for clinically realistic neuroprotective interventions.

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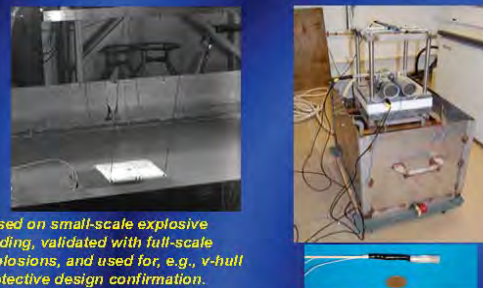
LATERAL FLUID PERCUSSION



- Pressure wave impacts the lateral parietal cortex
- Mild to moderate injury (small to moderate lesion volume)
- Diffuse axonal injury
- Chronic cellular inflammatory reactions
- Reproducible behavioral deficits

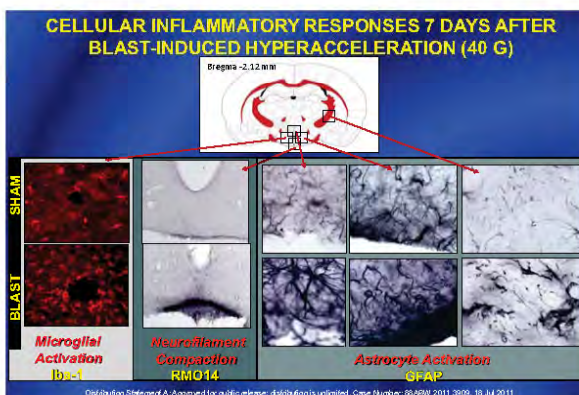
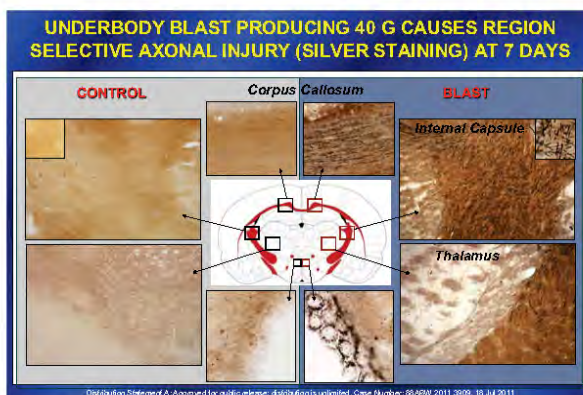
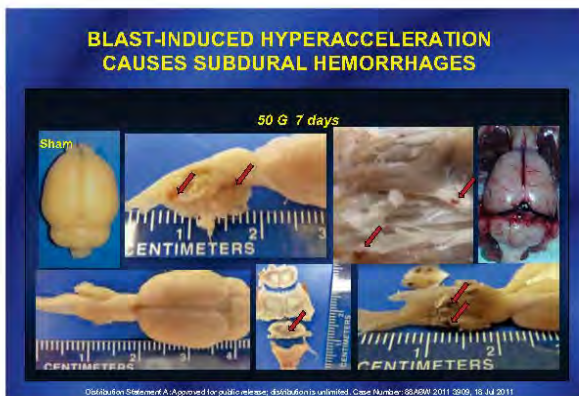
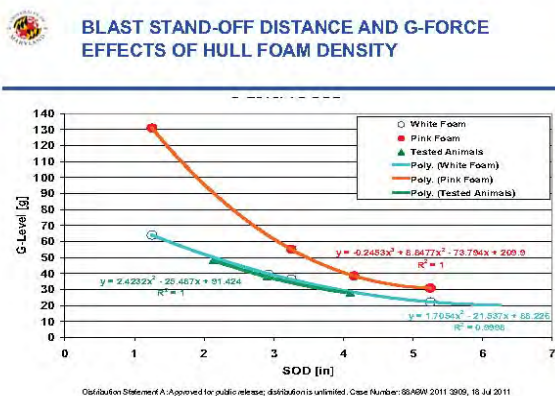
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UNDERBODY BLAST G-FORCE TBI EXPERIMENTS



Based on small-scale explosive loading, validated with full-scale explosions, and used for, e.g., v-hull protective design confirmation.

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UNDERBODY BLAST TBI MODEL

- Does AE-related hypobaric worsen outcomes after blast TBI, and, if so, when is the optimal time for AE after blast exposure?
 - 6-h delay before 6-h flight (0.75 atm)
 - 24-h delay
 - 7-day delay
 - Sham exposure

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UNDERBODY BLAST TBI MODEL

- Two flights worse than one?
 - Compare initial flight @ 24-h delay to initial flight followed by 10-h flight at 4 days after TBI.

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UNDERBODY BLAST TBI MODEL

- What is optimal ventilatory oxygenation on the initial flight?
 - Room air (mild hypoxia)
 - Supplemental O₂ to maintain normoxia
 - 100% O₂ (hyperoxia)

Note: We have found that hyperoxia can worsen outcome after rat contusion TBI, rat cerebral hypoxia, and canine cardiac arrest, due to exacerbation of oxidative stress and impairment of cerebral energy metabolism.

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UNDERBODY BLAST TBI MODEL

- How does AE-associated hypobaric affect intracranial pressure and brain tissue oxygenation?
 - Measure ICP during and after 6-h flight starting 1 day after TBI.
 - Measure brain tissue O₂ during and after 6-h flight starting 1 day after TBI.
 - Compare to measurements made at same times after TBI using sham hypobaric.

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LATERAL FLUID PERCUSSION TBI MODEL

- What is optimal time for AE after LFP exposure?
 - 6-h delay before 6-h flight (0.75 atm)
 - 24-h delay
 - 7-day delay
 - Sham exposure

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LATERAL FLUID PERCUSSION TBI MODEL

- Two flights worse than one?
 - Compare initial flight @ 24-h delay to initial flight followed by 10-h flight at 4 days after TBI.

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LATERAL FLUID PERCUSSION TBI MODEL

- Can neurohistopathologic outcomes and behavioral outcomes after TBI and hypobaria be improved by administration of a PARP inhibitor?
 - Compare outcomes after initial flight using two different doses of PJ34 to those using drug vehicle administered at 2 h after LFP.

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LATERAL FLUID PERCUSSION TBI MODEL

- How does AE-associated hypobaria affect intracranial pressure and brain tissue oxygenation?
 - Measure ICP during and after 6-h flight starting 1 day after TBI.
 - Measure brain tissue O₂ during and after 6-h flight starting 1 day after TBI.
 - Compare to measurements made at same times after TBI using sham hypobaria.

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FUTURE DIRECTIONS

- *Additional TBI models, e.g., free-field blast exposure, polytrauma*
- *Large animals, e.g., pigs*
- *Additional AE factors, e.g., vibration*
- *Magnetic resonance imaging & spectroscopy*
- *Molecular effects of hypobaria on the injured brain*
- *Combination therapies, e.g., targeting energy metabolism and inflammation*
- *Translation to clinical studies using measurements of ICP, PtO₂, MRI/MRS, serum biomarkers, and neurologic outcomes.*
- *Optimization of neurologic outcome after TBI for warfighter and civilian TBI victims.*

AFMS Medical Research Symposium, 2011, 19 Jul 2011

Critical Care Air Transport Team Severe Traumatic Brain Injury Short-Term Outcomes During Flight for Operations Iraqi Freedom/Enduring Freedom Between June 2007 and August 2010

711 HPW/USAFSAM-FEEG

Lt Col L. Renee Boyd

A retrospective chart review was conducted for 560 patient movements (i.e., Balad to Landstuhl, Landstuhl to Bethesda) transported by critical care air transport teams (CCATTs) with severe traumatic brain injuries (TBIs) between 1 June 2007 and 31 August 2010. Severe TBI was defined by the Brain Trauma Foundation and classified based on loss of consciousness that lasts for more than 24 hours, post-traumatic amnesia lasting for 7 days or longer, and a Glasgow Coma Score of 8 or less. Records were obtained from the CCATT Pilot Unit at Wilford Hall Medical Center, Lackland AFB, TX, and a standardized abstraction form was utilized that included the following: age; sex; nature of injury such as blast, blunt, or penetrating; additional traumatic injuries; type of mechanical ventilation; and intracranial monitor intervention (ventriculostomy or ICP CODMAN monitors). Results of this study serve to expand the available aeromedical knowledge by specifically looking at the area of TBI to allow refinement of CCATT training and provide data for the future development of guidelines for air transport for validating and clearing flight surgeons.




Critical Care Air Transport Team (CCATT) Severe Traumatic Brain Injury (TBI) Short-Term Outcomes During Flights for OIF/OEF between June 2007 and August 2010



Renee Boyd, MD, MPH, FACEP
 Lt Col, USAF, MC, SFS
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Topics

- Purpose
- Background – Literature Review
- Research Question
- Methods
- Results
- Limitations
- Conclusions
- References



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Purpose

- Describe the short-term outcomes of patients with severe traumatic brain injuries (TBI) managed by the USAF Critical Care Air Transport Teams (CCATTs) deployed in support of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) between 1 June 2007 and 31 August 2010.
- Collect data to develop guidelines for air transport for validating and clearing flight surgeons, provide refinement of CCATT training, improve air transport of TBI patients, and improve flight surgeon knowledge of the challenges these patients face in the operational flying environment.

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Background

- The Critical Care Air Transport Team's mission: Support combat casualties as a flying intensive care unit and augment the USAF aeromedical evacuation system.
- CCATT patients have received initial stabilization but still require evacuation to a higher level of care.
- CCATT is a three-member team: critical care physician, critical care nurse, and respiratory therapist.
- CCATTs can care for three intubated and three nonintubated patients (six total) for 72 h.

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Background

- CCATTs rotate with neurosurgeons and neurologists at C-STARS in neurosurgical intensive care units at the University of Cincinnati, in Cincinnati, OH, in management of severe TBI.
- Severe TBI – Glasgow Coma Scale (GCS) (3-8)
- Currently, CCATTs are taught to manage ventriculostomies and Codman intracranial pressure (ICP) monitors due to the current state of severe traumatic brain injuries seen mostly as a result of improvised explosive device (IED) blasts.

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Ventriculostomy

ETV Shunt

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Ventriculostomy

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Codman ICP Monitor



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Background – ICP ATLS 8th Edition

| | | |
|----------|---|----------|
| 10 mmHg | = | Normal |
| >20 mmHg | = | Abnormal |
| >40 mmHg | = | Severe |

- Sustained increased ICP leads to decreased brain function and poor outcome.
- Hypotension and low saturation adversely affect outcome.

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Background – Literature

- Dr. Phil Mason and Dr. James Eadie, Wilford Hall Medical Center (WHMC) conducted a prospective study of 72 CCATT patients from Iraq to Landstuhl Regional Medical Center (LRMC), Germany, in 2006.
 - Only 7 (10%) had severe TBI with an ICP monitor.
 - No detailed evaluation of these particular patients.

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Background – Literature

- Drs. Beninati, Henderson, King, and Lariet from WHMC conducted a retrospective chart review of 656 patient moves on the short-term outcomes of patients managed by USAF CCATTs deployed from 1 Mar 07 to 30 Jun 08.
- Of the 656 patients moves, there were 425 trauma patient moves with the mechanism of injury below:
 - Blast 309 (72.7%)
 - Penetrating 81 (19.1%)
 - Blunt 35 (8.2%)
- Of these trauma patient moves, there were 90 head injuries (not documented as severe TBI).

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Background – Literature



- Guidelines for the Management of Severe Traumatic Brain Injury – 3rd Edition, The Brain Trauma Foundation, 2007.
- Management of Patients with Severe Head Trauma – Joint Theater Trauma System Clinical Practice Guidelines, 30 June 2010.

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Research Question



- Which parameters (i.e., vent settings, FiO₂ requirements, hemodynamic stability, ICP, cerebral perfusion pressure (CPP), GCS, ventriculostomy or Codman monitor, mannitol, or hypertonic saline) are the key factors in transporting patients with traumatic brain injury to provide reasonable guidelines for validating and clearing flight surgeons in recommending air transport?

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Methods



- This was a retrospective chart review of all U.S. active duty, coalition, and U.S. civilian personnel with severe TBI transported by a USAF CCATT in support of the Global War on Terror (GWOT) between 1 Jun 07 and 31 Aug 10.
- Severe TBI, as defined by the Brain Trauma Foundation, is classified by loss of consciousness that lasts for more than 24 h, post-traumatic amnesia lasting for 7 days or longer, or a GCS of 8 or less.
- By these strict guidelines, this study only evaluated patients with a GCS of 8 or less.

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Methods



- Records were maintained at the CCATT Pilot Unit at WHMC.
- A standardized abstraction Excel spreadsheet was utilized and data were collected that included the following:
 - Age and sex of the patient (No names/SSN/cite number)
 - Date of injury
 - Theater of operation (i.e., OIF/OEF)
 - Name of hospital
 - Type of aircraft used for transport
 - Altitude restrictions




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Methods

- The nature of the injury was classified as blast, blunt, or penetrating.
- Additional injuries documented as polytrauma included:
 - Burns
 - Intraabdominal injuries
 - Intra-thoracic injuries
 - Amputations of extremities
 - Due to the volume of injuries, these were not broken down into categories.




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Methods


- Mode of ventilation, ventilator settings, and administration of vasoactive medications and blood products were documented.
- Hypertonic saline or mannitol administration.
- Monitoring included oxygen saturation, arterial line or noninvasive blood pressure monitoring, and ICP monitoring if a ventriculostomy or Codman ICP monitor was used.

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Methods

- Procedures were documented if they occurred in flight
 - Reattempt at endotracheal intubation
 - Cardioversion
 - Defibrillation
 - Pacing – Transcutaneous
 - Central venous access
 - Arterial line placement
 - Thoracostomy tube placement
 - CPR



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Methods

- Complications documented included:
 - Death
 - Desaturation < below 93% by pulse oximetry
 - Hypotension below a systolic blood pressure (SBP) of 90 mmHg or mean arterial pressure below 60 mmHg as recorded by arterial line or noninvasive mode
 - If ICP > 20 mmHg at any time during the flight
 - Recorded if CPP < 60 mmHg where CPP – mean arterial pressure (MAP) – ICP

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Methods

- The data were entered in an Excel spreadsheet for analysis.
- The potential risk of breach of confidentiality was safeguarded by only allowing the principal and associate investigator, Dr. Julio Lariet, access to the patients' records.
- Review of medical records was only performed in a secure area.



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Methods:

Inclusion/Exclusion Criteria

- **Inclusion criteria:** All U.S. active duty, coalition, and U.S. civilian personnel transported by a USAF CCATT mission in support of the GWOT who have suffered a severe TBI.
- **Exclusion criteria:** U.S. active duty, coalition, and U.S. civilian personnel transported by a USAF CCATT mission in support of the GWOT who have suffered a mild or moderate TBI and local foreign nationals with a head injury transported by CCATT.

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Methods: Sample Size

- Results for this study of the severe TBI trauma patients transported by CCATT between 1 Jun 07 and 31 Aug 10 were presented in a descriptive manner.
- As this was a descriptive study, there was no formal statistical analysis.
- 560 charts were evaluated with a diagnosis of brain injury.
- Due to the difficulty in coding, these included mild, moderate, and severe TBI.

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Methods: Sample Size

- Medical reasons such as subarachnoid hemorrhage or hemorrhagic stroke from hypertensive emergency and local foreign nationals (i.e. Afghans) with brain injury were not included in this initial review.
- Mild and moderate brain injuries were removed.

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Results

- End result: 192 patient moves with 121 patients met inclusion criteria for severe TBI with GCS ≤ 8 .
- 35 parameters were recorded to review the stability of patient movement.


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Military/Civilian Categories 192 Patient Moves

| | |
|------------------------------|----|
| U.S. Army | 93 |
| Blank (Unidentified Service) | 57 |
| U.S. Marine Corps | 20 |
| Contractor | 8 |
| U.S. Navy | 3 |
| Other Government Agency | 3 |
| Bulgaria | 2 |
| KBR Contractor | 2 |
| Peace Corps | 2 |
| U.S. Air National Guard | 2 |

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Sex/Age Categories 192 Patient Moves

| | |
|---------|-----|
| Males | 189 |
| Females | 3 |

- The average age for 121 patients was 30 years.

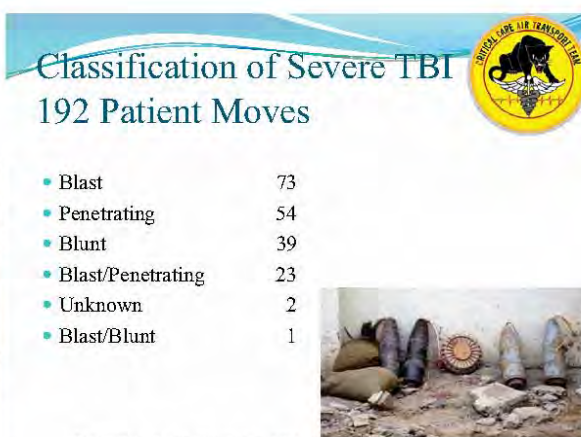
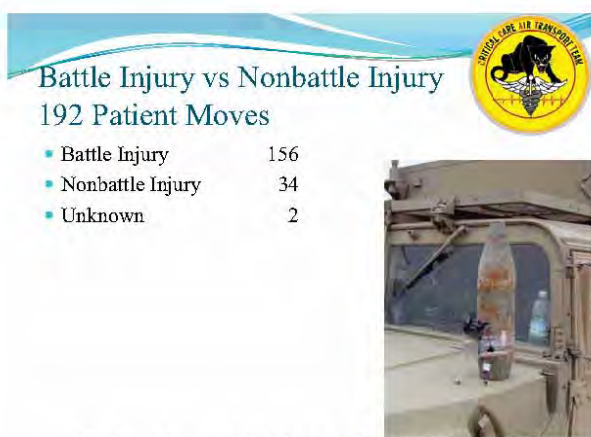
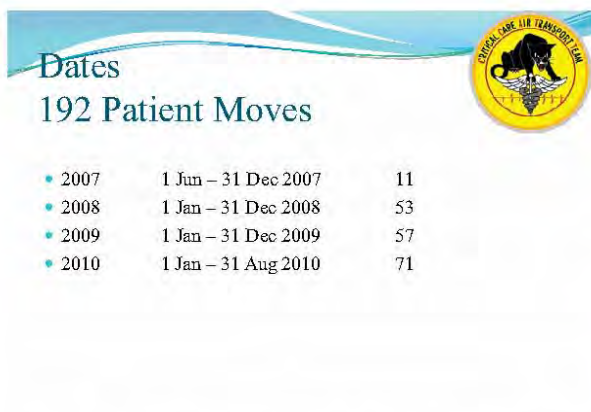
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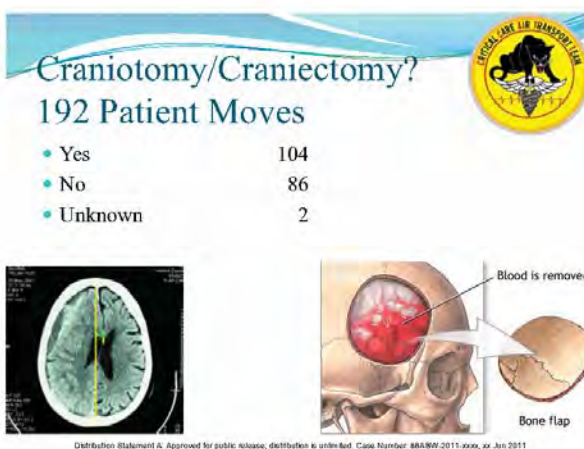
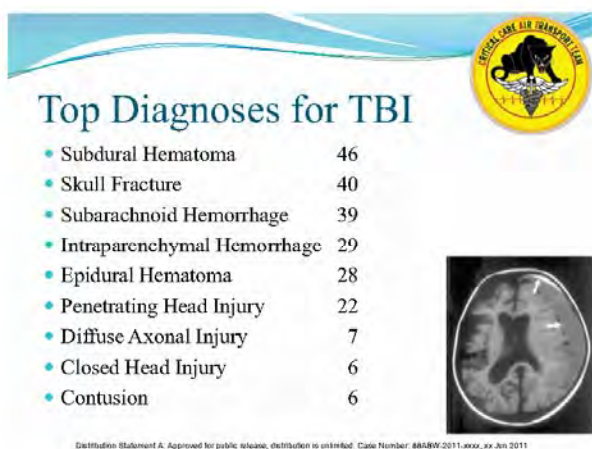
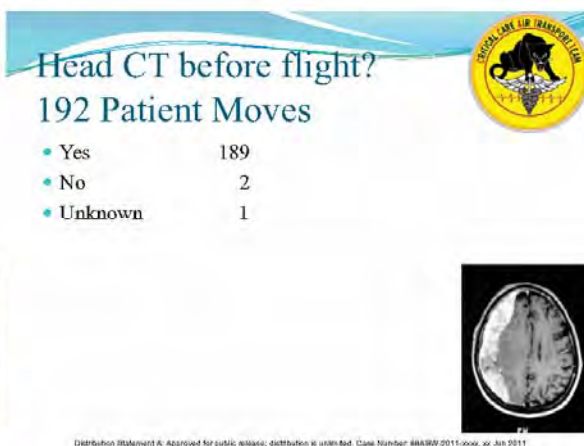
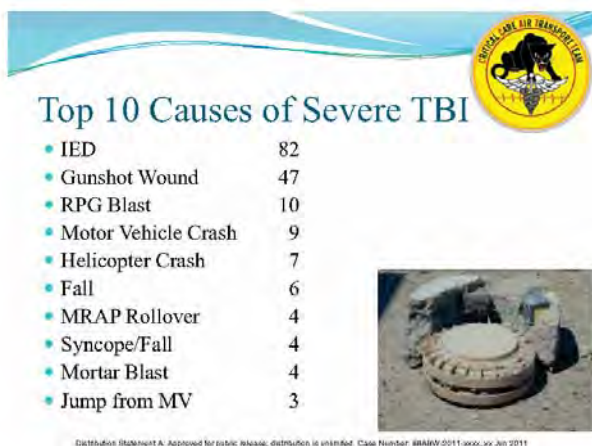


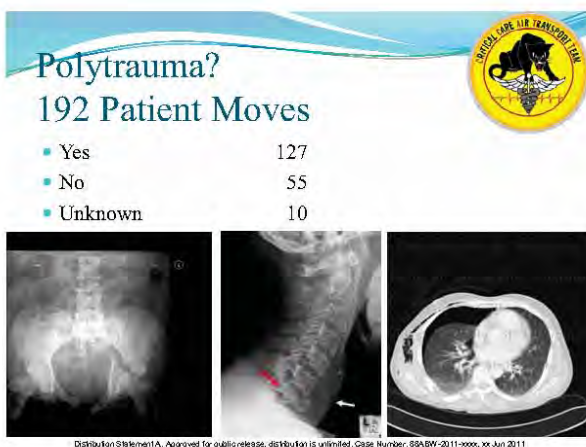
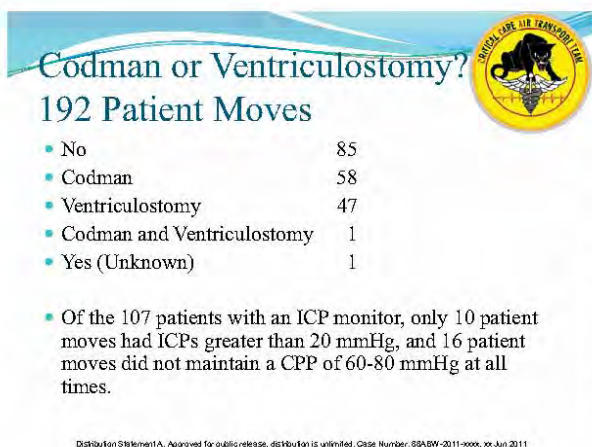
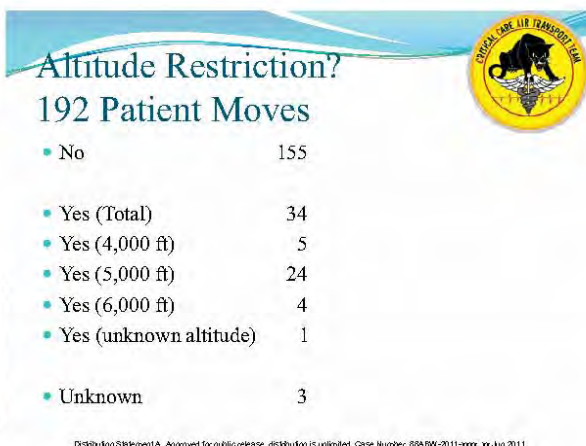
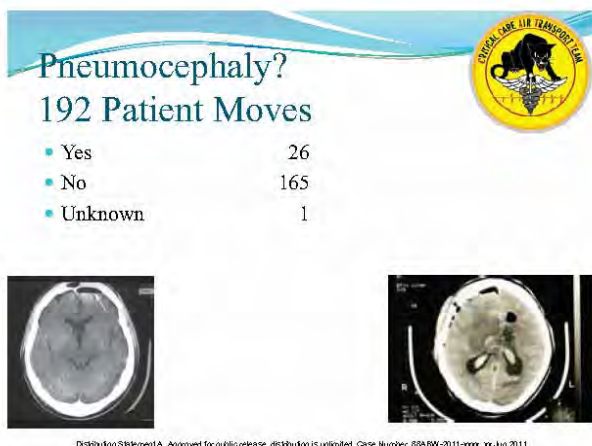
Nationality Categories 192 Patient Moves

| | |
|----------|-----|
| USA | 176 |
| Canada | 4 |
| Poland | 4 |
| Bulgaria | 2 |
| Georgia | 2 |
| Denmark | 1 |
| Romania | 1 |
| Blank | 1 |

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Ventilated?

192 Patient Moves

- Yes 180
- No (extubated) 12

- The 12 patients who were extubated were previously intubated patients in this study with severe TBI.



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Hemodynamically Stable?

192 Patient Moves

- No 45
- Yes 147



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Hemodynamically Unstable

45 Patient Moves

- Levophed 14
- Vasopressin/Levophed 8
- Phenylephrine 6
- Vasopressin 4
- Neosynephrine/Levophed 3
- Unknown 2
- Vasopressin/Dopamine 2
- Vasopressin/Neosynephrine 2
- Dobutamine/Vasopressin 1
- Neosynephrine/Epinephrine/Vasopressin 1
- Vasopressin/Levophed/Epinephrine 1
- Vasopressin/Phenylephrine/Levophed/Epinephrine 1

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Hypoxic? O2 sat < 93%

192 Patient Moves

- Yes 11
- No 181






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Hypertonic Saline?

192 Patient Moves

- Yes 68
- No 124




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Mannitol?

192 Patient Moves

- Yes 12
- No 180

• 4 patients received hypertonic saline and mannitol simultaneously.







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Seizures?

192 Patient Moves

- Yes 4
- No 188







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Seizure Prophylaxis?

192 Patient Moves

- Yes 92
- No 100






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Type of Seizure Prophylaxis?

92 Patient Moves

- Dilantin (Recommended) 46
- Fosphenytoin (Recommended) 22
- Keppra 22
- Gabapentin 1
- Valium 1



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Blood Products?

192 Patient Moves

- Yes 50
- No 142



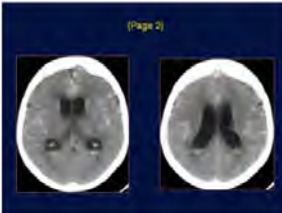


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Complications in Flight?

192 Patient Moves

- Yes 21
- No 171



(Page 2)

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21 Complications in Flight



- Central diabetes insipidus (hyperglycemia/Na-170) 7
- Hypoxia /increased FiO2 (80-100 %) requirement 4
- Hypotension and hypoxia 2
- Hypotension and catastrophic brain injury 1
- Hypertension (SBPs 180-190) 1
- Hypertension and elevated ICP due to turbulence 1
- Cerebral salt wasting 1
- Temp 105 °F 1
- Cushing's reflex 1
- Start norepinephrine to increase MAPs 1
- ICP increased to 45 mmHg 1

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Aircraft Flown?

192 Patient Moves

| | |
|-----------|----|
| • C-17 | 66 |
| • C-130 | 21 |
| • KC-135 | 18 |
| • Unknown | 87 |






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Theater of Operation?

192 Patient Moves


| | |
|-----------|-----|
| • OEF | 115 |
| • OIF | 54 |
| • Unknown | 23 |

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Limitations


- There was limited documentation due to the difficulty in interpreting physicians' handwriting.
- Due to time constraints and number of charts that were reviewed, there was no detailed review of polytrauma associated with severe TBI.
- It was unclear why some patients were on vasopressin (central diabetes insipidus or hypotension).
- There was no long-term follow-up for these patients to determine outcomes.



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Conclusions - Who can fly?

- Maintain hemodynamic stability, a SBP > 90 – Reconsider transport of patient on 3-4 pressors.
- Maintain an oxygen saturation > 90-93%.
- Current literature supports that ICP of 20-25 mmHg warrants treatment with either pharmacologic means such as analgesics (morphine, fentanyl), sedation (versed), paralysis (vecuronium), or 3% NaCl protocol or mannitol or ventriculostomy.
- According to the Brain Trauma Foundation, ICP may be related to the risk of herniation, and some of the future goals in research are to approximate a "herniation pressure."
- Reconsider transport of patients with ICP > 40 mmHg.



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Conclusions- Who can fly?

- With respect to cerebral perfusion pressure, it is generally agreed by the Brain Trauma Foundation that the critical threshold of ischemia is 60 mmHg, but again another goal of research is to find this vital number.
- Before we can significantly improve outcomes, it will be necessary to not only look and critically evaluate current treatment recommendations but also to look at the long-term outcomes of these patients to determine optimal parameters and determine a time as to when these patients can safely fly.

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Closed Loop Control of FIO₂ in Multiple Trauma Patients

711 HPW/USAFSAM-ETS

Mr. Richard Branson

PURPOSE: Closed loop control (CLC) of inspired oxygen concentration (FIO₂) may maintain oxygenation and conserve oxygen.

Methods: In a randomized cross-over trial, we compared a 4-hr period using standard of care (SOC) physician-directed FIO₂ control to 4 hr of CLC of FIO₂ in trauma patients. CLC was accomplished using a proportional–integral–derivative (PID) controller targeting oxygen saturation (SpO₂) at 94±2%. The PID controller manipulated FIO₂ to maintain the SpO₂ target. A paired t-test was used to compare the variables between SOC and CLC groups.

Results: A total of 95 patients (82 men, 13 women; 76 white, 18 African-American, and 1 Asian) were enrolled. Mean [± standard deviation (SD)] age was 36±12 yr and mean ISS was 32 (range 16-50).

Mean oxygen usage was 1.5 L/min in CLC and 2.84 L/min during SOC (p< 0.0001). The mean (± SD) of total time in minutes per patient per 4-hr period with SpO₂ ≤ 88% was 0.55±1.37 with a range of 0-12.2 min in CLC and 1.28±2.64 in SOC with a range of 0-17.3 min (p<0.002). There were 91 low SpO₂ events in the SOC group and 77 in the CLC group.

CONCLUSION: CLC of FIO₂ provides consistent control of the target SpO₂ without clinician intervention, which may offer advantages in the en route care setting.

Closed Loop Control of FiO_2

*Rich Branson, MSc RRT
Professor of Surgery*

Sponsored by the Office of Naval Research



Background

- Oxygen represents 20%-30% of the weight of supplies for transport.
- Liquid oxygen provides the greatest volume but has storage, position, and off gassing issues.
- Cylinders are heavy and carry an explosive risk.
- Reducing oxygen usage has potential advantages.



How Much Oxygen Do Casualties Require?

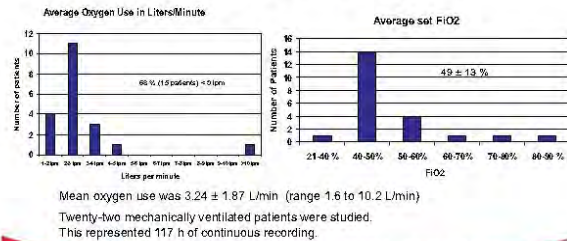
- The prehospital use of oxygen is not typically governed by objective measurements.
- Oxygen requirements in trauma are not known.
- Hypoxemia is not always treatable by oxygen delivery (e.g., airway obstruction, pneumothorax).

Oxygen Use in CCATT

- Define oxygen requirements of critically ill/injured warfighters requiring mechanical ventilation and transport in hypobaric/hypoxic environments.



Oxygen Use in CCATT



Hypothesis

A closed loop controller for oxygen provides appropriate oxygen saturation, prevents hypoxemia, and reduces oxygen use.

Study Goals

- Closed loop control of inspired oxygen concentration (FiO_2) using arterial oxygen saturation (SpO_2) can
 - Reduce oxygen usage during transport.
 - Reduce the number of low SpO_2 conditions.
 - Provide normoxemia vs. hyperoxemia.

Clinical Implications

- Reduced oxygen usage will reduce the weight and cube of required oxygen stores.
- Prevention of hypoxemia will improve outcome (a single episode of hypoxemia in closed head injury is associated with negative outcomes.)
- Closed loop can provide appropriate oxygenation for the patient from injury to definitive care.

Methods

- Trauma patients age 18-65
- Informed consent as soon as possible post-trauma
- Randomized, crossover trial of closed loop control of FiO_2 vs. manual control
- 4 h in each arm of the trial
- Arterial blood gas sampling every 2 h
- Hemodynamic parameters every 2 h
- All ventilator parameters and SpO_2 /heart rate (HR) recorded every 5 s to electronic data (.csv)

Safety & Efficacy

- Safety – Prevention of hypoxemia ($\text{SaO}_2 \leq 88\%$)
- Efficacy – Ability of controller to maintain SaO_2 target ($94\% \pm 2\%$)
- Oxygen conservation

Description

- FiO_2 automatically adjusted based on SpO_2 , SpO_2 -target difference and trends in SpO_2 .
- SpO_2 target is 94% (adjustable).
- If $\text{SpO}_2 \leq 88\%$, FiO_2 increases to 1.0.
- A combination of fine and coarse control.
- If SpO_2 signal is lost, FiO_2 remains constant.
- If FiO_2 increases $> 10\%$, an alert is provided.



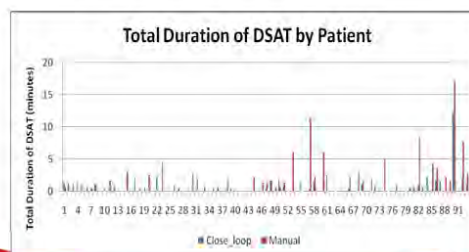
Closed Loop $\text{FiO}_2/\text{SpO}_2$

- Total enrollment $n = 95$
- Gender 84 men, 16 women
- Ethnicity 73 Caucasian, 21 African-American, 1 Asian
- Mean age - 35.3 ± 11.7
- Mean Glasgow Coma Score - 10.8 ± 3.9
- Mean Injury Severity Score - 34 ± 13
- Mean APACHE II - 20 ± 7

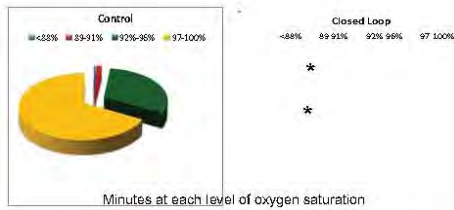
Closed Loop $\text{FiO}_2/\text{SpO}_2$

| | Control 1:1 | Control 1:2 | Closed Loop 1:1 | Closed Loop 1:2 |
|----------------------------------|------------------|------------------|------------------|------------------|
| pH | 7.45 ± 0.03 | 7.42 ± 0.03 | 7.44 ± 0.03 | 7.44 ± 0.04 |
| PaCO_2 (mmHg) | 40.4 ± 4.7 | 41.1 ± 4.3 | 38.8 ± 4.5 | 38.6 ± 4.3 |
| PaO_2 (mmHg) | 97.7 ± 21.7 | 96.0 ± 16.8 | 99.9 ± 17.6 | 96.4 ± 10.7 |
| SaO_2 (%) | 95.2 ± 2.3 | 95.2 ± 2.29 | 95.3 ± 2.0 | 95.5 ± 2.0 |
| FiO_2 (%) | 94.5 ± 0.71 | 8.42 ± 0.71 | 8.37 ± 0.17 | 9.55 ± 0.34 |
| PEEP (cmH ₂ O) | 8.4 ± 2.6 | 8.7 ± 2.4 | 8.4 ± 2.6 | 8.4 ± 2.6 |
| Respiratory rate (bpm) | 15.8 ± 3.2 | 15.4 ± 3.4 | 15.2 ± 3.2 | 15.4 ± 2.9 |
| \dot{V}_T (mL) | 456 ± 84 | 483 ± 94 | 485 ± 94 | 488 ± 91 |
| \dot{V}_T (cmH ₂ O) | 28.2 ± 8.8 | 30.6 ± 6.5 | 29.5 ± 4.5 | 29.1 ± 5.1 |
| IP (mmHg) | 128 ± 24.4 | 129.7 ± 28.0 | 127.6 ± 27.7 | 131.6 ± 29.8 |
| DP (mmHg) | 65.8 ± 8.7 | 63.8 ± 9.1 | 59.8 ± 8.7 | 65.5 ± 10.3 |
| MAP (mmHg) | 82.6 ± 13.1 | 80.7 ± 12.5 | 78.7 ± 10.7 | 80.7 ± 11.5 |
| HR (bpm) | 102.4 ± 18.5 | 100 ± 16.5 | 100 ± 21 | 100.7 ± 19.7 |

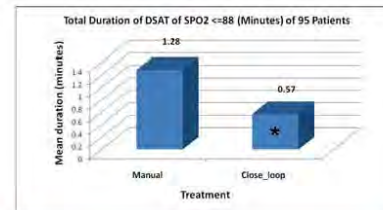
Duration of Desaturation per Patient



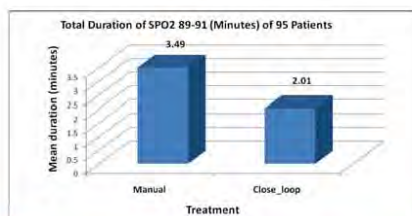
Closed Loop $\text{FiO}_2/\text{SpO}_2$



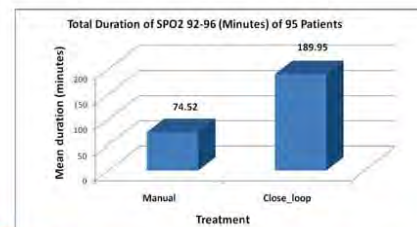
Hypoxemia



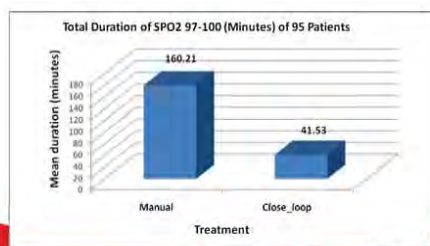
Below Target



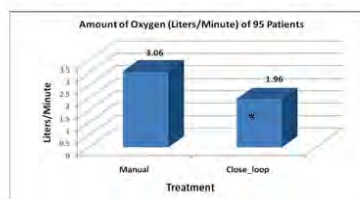
Time at Target



Hyperoxemia



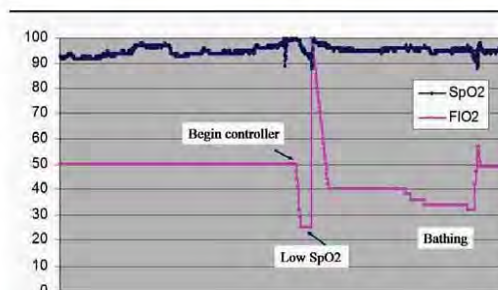
Closed Loop FiO₂/SpO₂

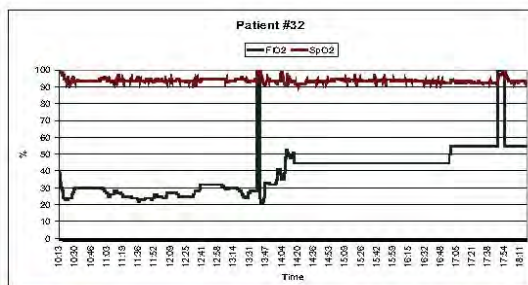
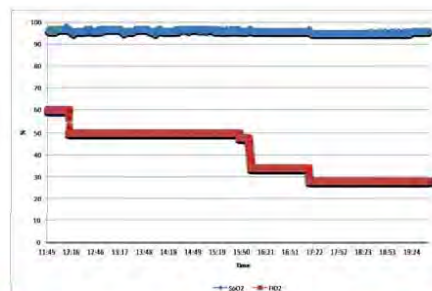
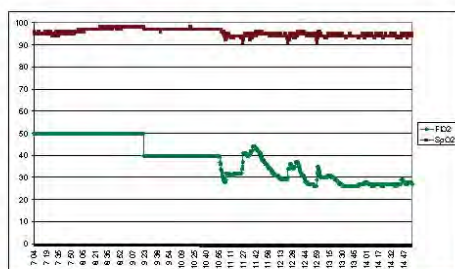


Oxygen conservation
 Closed loop 0.02-5.9 L/min Manual 0.9-7.74 L/min
 * p < 0.0001

FiO₂ Changes

- Closed loop 95.2 changes per 4-h period
- Control 4.4 changes per 4-h period
- 95 ± 49 vs. 4.46 ± 2 (p < 0.0001)





Future Directions

POGS/Ventilator:

Small, lightweight

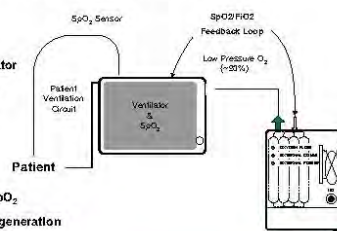
Integrated with a ventilator

Comprehensive modes of ventilation

Supplemental O₂ administration

Closed loop control of oxygenation using SpO₂

Feedback control of O₂ generation





Acknowledgments

This work would be impossible without

- Mike Given, Ph.D. – ONR
- Chris Blakeman, Dario Rodriguez, Carolina Rodriguez – UC
- George Beck, Dorian Lacroy – Impact
- Men and women of the U.S. Armed Forces



Prehospital Oxygen Use in Civilian Trauma Care

711 HPW/USAFSAM-ET

Mr. Richard Branson

BACKGROUND: Trauma patients often receive prehospital oxygen (O₂) without evidence of hypoxemia. Knowing the need for prehospital O₂ could assist military planners. **METHODS:** A convenience sample of injured adults taken to a trauma center by six emergency medical services (EMS) agencies was studied. During transport, O₂ saturation (SpO₂) was continuously recorded. Prehospital and in-hospital O₂ use were recorded. A conservative threshold for O₂ need (SpO₂<95%) was used to estimate maximum prevalence and defined per local EMS protocols. Analysis using the TCCC threshold of SpO₂<90% was also performed. Categorical comparisons used chi-square or Fisher's exact tests; medians were compared with the Mann-Whitney U test. **RESULTS:** Of 290 screened patients, 154 had complete data. The median age was 37 (range 18-84), 77/154 (50%) were white, and 121/154 (79%) were male. The median injury severity score (ISS) was 5 (1-43), 55/154 (36%) had a penetrating injury, and 82/154 (53%) were admitted. During treatment 128/154 subjects (83%, 95% confidence interval 76%-88%) had a need for O₂ where 113/154 (73%) had SpO₂<95%, 52 (34%) were <90%, and 86/154 subjects (67%) received O₂ during EMS transport. Those with O₂ need were older (38 vs. 27 years; p=0.019) and had higher ISS scores (9 vs. 1; p=0.001). There was no difference in O₂ need for those with or without penetrating (36% vs. 40%, p=0.684) or chest (27% vs. 19%, p=0.469) injuries.

CONCLUSION: At threshold of SpO₂<95% and SpO₂<90%, 30%-50% of civilian trauma patients required O₂. The need for O₂ remains sufficient to deploy some oxygen for those casualties who may benefit from supplemental oxygen.

Prehospital Oxygen Use in Civilian Trauma Care

Rich Branson, MSc, RRT
Professor of Surgery

Sponsored by the Department of the Navy,
MRMC, and 711th HPW USAF

How Much Oxygen Do Casualties Require?

- The prehospital use of oxygen is not typically governed by objective measurements.
- Oxygen requirements in trauma are not known.
- Hypoxemia is not always treatable by oxygen delivery (e.g., airway obstruction, pneumothorax).

How Much Oxygen Do Trauma Patients Require?

- Prehospital trauma life support (PHTLS)
 - Administer 85% oxygen if respiratory rate is 20-30/min.
 - "All patients with suspected traumatic brain injury should receive supplemental oxygen."
 - If pulse oximetry is not available, oxygen should be provided with a non-rebreather mask.
 - "SpO₂ should be at least 90%, 95%, or higher being optimal."
 - "Oxygen saturation (SpO₂) should be monitored in virtually all trauma patients." SpO₂ target = 95%.

How Much Oxygen Do Trauma Patients Require?

- Most combat casualties do not require supplemental oxygen, but administration of oxygen may be of benefit for the following types of casualties:
 - Low oxygen saturation by pulse oximetry
 - Injuries associated with impaired oxygenation
 - Unconscious casualty
 - Casualty with traumatic brain injury (maintain oxygen saturation > 90%)
 - Casualty in shock
 - Casualty at altitude

Tactical Combat Casualty Care Guidelines
1 November 2010

Methods



Results

- During the 12-mo study, 290 patients were screened.
- 154 patients met criteria and had complete data.
- Median age 37 (18-84) yr.
- Males – 79%.
- Caucasian – 50%, African-American – 50%.
- Median Injury Severity Score 5 (1-43).
- Penetrating injury – 36%, blunt injury 64%.
- 82 of 154 patients were admitted to the hospital.

Results

- Based on EMS observation and SpO₂ 86 of 154 (67%) patients received oxygen
- Using a threshold of 95% SpO₂ – 113/154 (73%) patients had relative hypoxemia
- Using a threshold of 90% SpO₂ – 52/154 (34%) patients had relative hypoxemia
- Patients who received oxygen were
 - Older 38 vs. 27 years (p=0.0019)
 - Greater ISS 1 vs. 9 (p=0.0001)

Results

- No difference in oxygen delivery with penetrating vs. blunt injury (36% vs. 40%, p=0.684).
- No difference in oxygen delivery with thoracic vs. nonthoracic injury (27% vs. 19%, p=0.469).

Conclusions

- Oxygen needs in civilian trauma based on an SpO₂ of <90% occur in 30% of patients.
- The amount of oxygen required to reverse hypoxemia is elusive.
- Civilian trauma patients do not suffer the degree of chest injury or exsanguination seen in theater.

Acknowledgments

- This work would be impossible without
 - Jason McMullan, Chris Blakeman, Dario Rodriguez, Carolina Rodriguez – UC
 - Clinical Study Assistants Department of Emergency Medicine



Task Saturation in Critical Care Air Transport Team Advanced Training

11 HPW/USAFSAM-ETS

Dr. Timothy Pritts

BACKGROUND: An important part of the current combat casualty care paradigm is tactical and strategic aeromedical evacuation of critically ill patients. Care of critically ill patients in this environment, as delivered by Critical Care Air Transport Teams (CCATTs), is challenging and involves the execution of a myriad of tasks. The current experience of CCATT has led to increasing understanding of the challenges of task saturation in complex environments, but the occurrence of task saturation in the CCATT training environment is unknown. This study will increase our knowledge of the occurrence and nature of task saturation during simulated CCATT missions and will provide the groundwork for potential improvements in CCATT training to mitigate the effect of task saturation on patient care. **HYPOTHESIS:** We hypothesize that task saturation occurs during simulated CCATT missions.

STUDY DESIGN: We seek to increase our understanding of task saturation in the CCATT environment. This will be accomplished through observation of patient care during simulated CCATT missions from at least four consecutive CCATT advanced classes. This will establish the practicability of task saturation occurrence determination during simulated CCATT missions. We will then determine the potential effects of task saturation on loss of team effectiveness during simulated CCATT missions. We will gather data from four consecutive CCATT advance classes. Data will be obtained prospectively but analyzed in detail by a panel of educational and team training experts in a retrospective fashion over 6 months.



Task Saturation in Critical Care Air Transport Team (CCATT) Advanced Training

Timothy A. Pritts, MD, PhD
University of Cincinnati

Every Airman a Force Multiplier
August 2011 AFMS Research Symposium

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Task Saturation

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- ✓ Occurs when the number or complexity of task requirements exceeds the ability to execute these tasks at a high level.
- ✓ May occur during any complex work set.
- ✓ May lead to degradation of the effectiveness of patient care delivery.
- ✓ May increase with increasing environmental complexity.

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Types of Task Saturation

Every Airman a Force Multiplier



Gap in knowledge:

The rate of occurrence of task saturation in CCATT advanced training is unknown.

Question:

How often does task saturation occur? What are the risk factors?

Hypothesis:

We hypothesize that increased understanding of task saturation will enable better CCATT training and team function.

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✓ Channeling

- ✓ Lose the forest in the trees

✓ Disengagement

- ✓ Loss of function

✓ Compartmentalization

- ✓ Inappropriate prioritization and delegation

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4



Not a technical skills issue

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✓ Leadership

- ✓ Delegate tasks
- ✓ Communicate effectively
- ✓ Gather information

✓ Communication

- ✓ Planning and prioritization
- ✓ Use of closed loop communication
- ✓ Double checks

✓ Re-evaluation

✓ Mutual performance monitoring

- ✓ Clear roles and responsibilities
- ✓ Mutual respect
- ✓ Avoid fixation errors
- ✓ Constructive intervention
- ✓ Knowledge sharing

Manuscript for Distribution, 1101

Distribution Statement A, Approved for public release; distribution is unlimited. Case Number: 6ANW2011-4081, 22 Jul 2011



Not a technical skills issue

Every Airman a Force Multiplier

✓ Guideline Maintenance

- ✓ Use of cognitive aids
- ✓ Coordinate tasks
- ✓ Communicate effectively

Manuscript for Distribution, 1101

Distribution Statement A, Approved for public release; distribution is unlimited. Case Number: 6ANW2011-4081, 22 Jul 2011



Ready for Prime Time?

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- ✓ We hypothesized that new surgical interns may not be adequately prepared to evaluate and manage potential patient care emergencies

Continued: Surgical Interns, 1101

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METI – ECS SIMULATOR

Every Airman a Force Multiplier



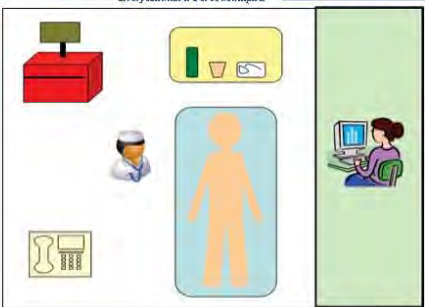
Continued: 2. Integration, 1101

Distribution Statement A, Approved for public release; distribution is unlimited. Case Number: 6ANW2011-4081, 22 Jul 2011

- Computer interface
- Generates vital signs which are reproduced on a monitor
- Physical exam findings
- Human controller alters physiologic status in real-time
- Equipped with microphone and speaker

IN-PATIENT ROOM SETUP

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CASE SCENARIOS

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- Each participant received one scenario
 - ▼ Post-op a fib, pneumothorax, early sepsis
- Typical “patient sign out”
 - ▼ Patient name, age, and procedure performed
- Participants “called to the bedside”

Coffey et al. / Supplemental Material, 2008
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EVALUATION

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- Initial assessment of patient status
- Assess and monitor a patient undergoing obvious deterioration
- Communication with team members and upper-level resident
- Basic emergency patient management principles

Coffey et al. / Supplemental Material, 2008
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PGY 1 RESIDENTS MAY NOT IDENTIFY PHYSIOLOGIC COMPROMISE DURING INPATIENT EMERGENCIES

| Score (%) How performed? | 1 Did not | 2 Poorly | 3 Correctly |
|----------------------------------|--------------|-------------|----------------|
| Requests updated vitals | 9 (56) | 2 (13) | 5 (31) |
| Performs pulse exam and reassess | 4 (25) | 10 (63) | 2 (13) |
| Listens for breath sounds | 4 (27) | 3 (20) | 8 (53) |
| Places patient on monitor | 11 (73) | - | 4 (27) |
| Monitors blood pressure | 8 (53) | 4 (27) | 3 (20) |

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INTERNS MAY NOT COMMUNICATE EFFECTIVELY

| Score (%) How performed? | 1 Did not | 2 Poorly | 3 Correctly |
|--|--------------|-------------|----------------|
| Identifies self to patient/RN | 8 (50) | - | 8 (50) |
| Delegates/communicates tasks to team members | 3 (19) | 11 (69) | 2 (12) |
| Calls appropriately for help from additional staff (any) | 10 (67) | 2 (13) | 3 (20) |
| Communicates with upper-level resident | 10 (63) | 3 (19) | 3 (19) |

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PGY 1 RESIDENTS DID NOT UTILIZE BASIC INTERVENTIONS DURING EMERGENCY SCENARIOS

| Score (%) How performed? | 1 Did not | 2 Poorly | 3 Correctly |
|-----------------------------|--------------|-------------|----------------|
| Evaluates airway | 7 (44) | 4 (25) | 5 (31) |
| Administers O ₂ | 7 (44) | 5 (31) | 4 (25) |
| Acknowledges IV access | 4 (25) | 7 (44) | 5 (31) |
| Administers IV therapy | 4 (27) | 6 (40) | 5 (33) |

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CONCLUSIONS

- Interns have the technical skills
...and the knowledge
- Without structured educational process or experience, they do not know how to use this skill-set
- Many of the short comings are due to, or exacerbated by task saturation

Continued on next page

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Subsequent work with Surgical ICU fellows, residents, nurses, respiratory therapists, and pharmacists suggested that task saturation is a common occurrence in this setting

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Does AE Represent a Complex Environment?

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Is Air Transport Complex?

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- ✓ **Rotary wing transport:**
 - ✓ Lehman et al J Trauma 2009
 - ✓ 50% patients mechanically ventilated
 - ✓ 20% vasoactive medications
 - ✓ In-flight clinical deterioration occurring on 30% of flights
 - ✓ Equipment failure in 17% of flights
- ✓ **Civilian air transport:**
 - ✓ Critical events occur at least once for every 12.6 hours of transport time

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Does AE Represent a Complex Environment?

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- ✓ **Taken together, this data suggests that the CCATT environment may be highly susceptible to events secondary to task saturation**

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Gap in knowledge:

The rate of occurrence of task saturation in CCATT advanced training is unknown.

Question:

How often does task saturation occur? What are the risk factors?

Hypothesis:

We hypothesize that increased understanding of task saturation will enable better CCATT training and team function.

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Experimental Design

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- ✓ Perform observational study of CCATT simulation training sessions.
- ✓ Review video and patient care data from at least four CCATT advanced classes.
- ✓ Each simulation session will be reviewed and evaluated by at least two of the co-investigators.



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CCATT TASK SATURATION STUDY DATA COLLECTION

| Category | Subcategory | Report | Notes |
|--------------------------|----------------------------|---------------|-------|
| Teamwork | Leadership | 125 45578 9 0 | |
| | Team cohesion | 125 45578 9 0 | |
| | Teamwork | 125 45578 9 0 | |
| | Communication | 125 45578 9 0 | |
| | Coordination of activities | 125 45578 9 0 | |
| Communication | Planning | 125 45578 9 0 | |
| | Task assignment | 125 45578 9 0 | |
| | Use of shared team | 125 45578 9 0 | |
| | Teamwork | 125 45578 9 0 | |
| | Teamwork | 125 45578 9 0 | |
| Medical care/monitoring | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| Management of resources | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| Task management | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| Supervision of resources | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| Observation of resources | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |
| | Observation | 125 45578 9 0 | |

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Current Status

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- ✓ Team assembled
 - ✓ Education and Critical Care Experts
 - ✓ CCATT cadre
- ✓ Research strategy finalized
- ✓ Awaiting final IRB approval

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Conclusions

Every Airman a Force Multiplier

- ✓ Task saturation, or errors attributable to task saturation, is likely common in complex medical environments
- ✓ Occurrence of task saturation in CCATT training or missions is unknown
- ✓ Ability to mitigate effects of task saturation important to continue to raise the level of care

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The Impact of Prophylactic Fasciotomy Following Porcine (*Sus scrofa*) Hind Limb Ischemia/Reperfusion Injury

Brooke Army Medical Center

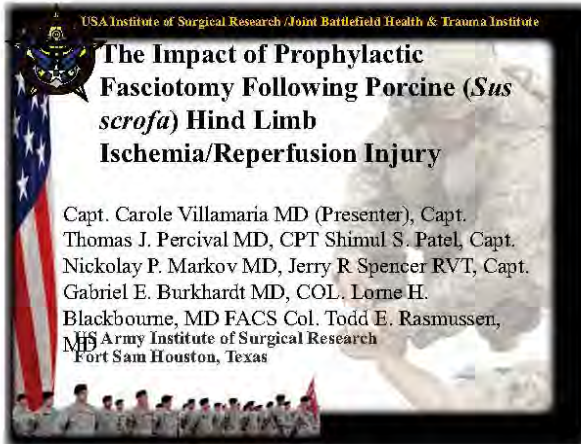
Capt Thomas Percival

BACKGROUND: Prophylactic fasciotomy has been used alleviate compartment syndrome after ischemia reperfusion injury. It has been purposed that prophylactically treating compartment syndrome will improve neuromuscular recovery of the limb therefore improving functional limb outcome. The purpose of this study is to quantify the neuromuscular recovery after prophylactic fasciotomy in a porcine model of hemorrhage and hind limb ischemia. **METHOD:** Swine (*Sus Scrofa*; 76 +/-6kg) were randomly assigned to no fasciotomy or prophylactic fasciotomy after ischemia via external iliac artery occlusion and arteriotomy. Class III shock was induced via a 35% blood volume variable rate hemorrhage and external iliac artery repair was achieved after 0, 3, or 6 hours of ischemia. Prophylactic fasciotomy of the anterior compartment was performed at the time of reperfusion. Compound motor action potential, sensory nerve action potential, nerve conduction velocity and gait testing was evaluated during the 14-day survival period to calculate the composite physiologic model of recovery (PMR). Necropsy was performed for evaluation of nerve and muscle histology. **RESULTS:** In hemorrhage alone, according to the PMR the recovery was 94+/-28%, 63+/-37% and 55+/-44% at 0, 3 and 6 hours of ischemia respectively. A significant difference was noted between 0 and 6 hours of ischemia ($p<0.05$). With fasciotomy, a recovery of 97+/-72%, 98+/-80% and 42+/-39% was noted after 0, 3 and 6 hours of ischemia. Compound motor action potential showed the greatest decrement with ischemic insult. Histologic analysis is currently on going. **CONCLUSION:** This study demonstrates the feasibility of fasciotomy in a porcine model. It validates the previous model of functional limb outcome with hemorrhage and hind limb ischemia in a porcine model and shows an apparent trend towards improved functional limb outcome if vascular repair and prophylactic fasciotomy are performed within 3 hours of ischemic time.

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

The Impact of Prophylactic Fasciotomy Following Porcine (*Sus scrofa*) Hind Limb Ischemia/Reperfusion Injury

Capt. Carole Villamaria MD (Presenter), Capt. Thomas J. Percival MD, CPT Shimul S. Patel, Capt. Nickolay P. Markov MD, Jerry R. Spencer RVT, Capt. Gabriel E. Burkhardt MD, COL. Lorne H. Blackburne, MD FACS Col. Todd E. Rasmussen, MHS Army Institute of Surgical Research Fort Sam Houston, Texas



USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Disclaimers

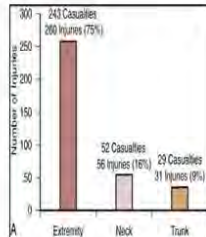
This study has been conducted in compliance with the Animal Welfare Act, the implementing Animal Welfare Regulations, and the principles of the Guide for the Care and Use of Laboratory Animals.

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Background

- Approximately 12% of injuries in Iraq and Afghanistan are Vascular Injuries
- 75% of these injuries are in the extremity



| Body Part | Casualties | Injuries | Percentage |
|-----------|------------|----------|------------|
| Extremity | 243 | 260 | 75% |
| Neck | 52 | 56 | 16% |
| Torso | 29 | 31 | 9% |

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Background

- The classic teaching is that a patient has approximately six hours of ischemia before irreversible damage
- Animal Data suggests that the time until irreversible damage with ischemia in the absence of hemorrhage is between 3 and 6 hours
- Survival models of ischemia/reperfusion injuries are lacking



Background

- Prolonged ischemia is associated with compartment syndrome, which potentiates the damage of the initial insult
- The treatment of compartment syndrome is fasciotomy
- The efficacy of fasciotomy has been proven in non-survival animal models at various ischemic intervals in the absence of hemorrhage

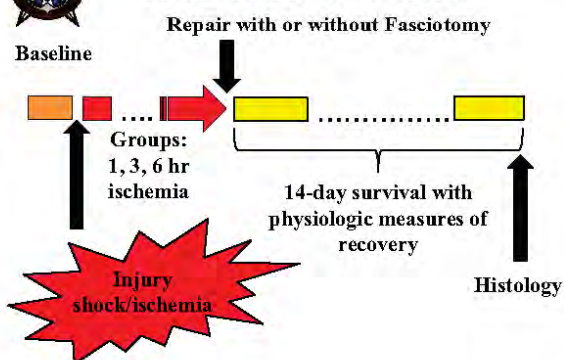


Objective

- Describe a large animal model of vascular injury characterizing neuromuscular recovery following class III hemorrhagic shock and ischemic intervals
- Characterize an extremity ischemic threshold to allow understanding of the importance of timing of restoration of flow following vascular injury
- Demonstrate the impact of prophylactic fasciotomy on ischemic threshold of the limb and improve neuromuscular recovery

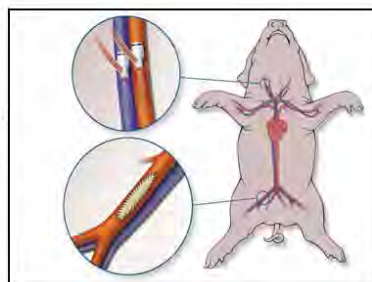


Methods: Model Overview



Methods: Hemorrhage

Volume-controlled hemorrhage (20 minutes/ 35%)

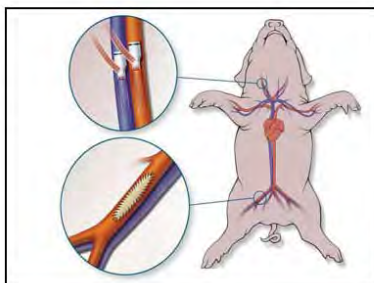




Methods: Arterial Repair

Reperfusion via
arteriotomy and
patch angioplasty

Duplex
surveillance



Methods

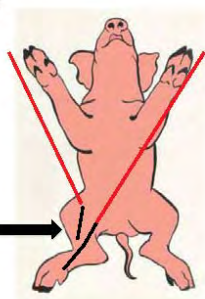


Methods: Fasciotomy

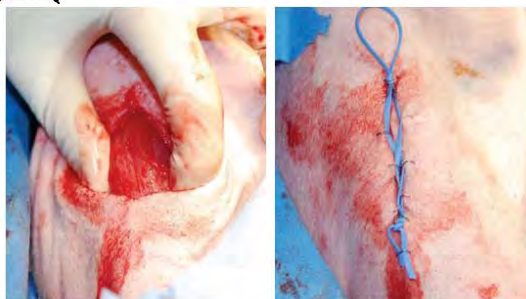
Peroneal(motor)
Nerve

Tibial (mixed)
Nerve

Fasciotomy Site



Methods: Fasciotomy



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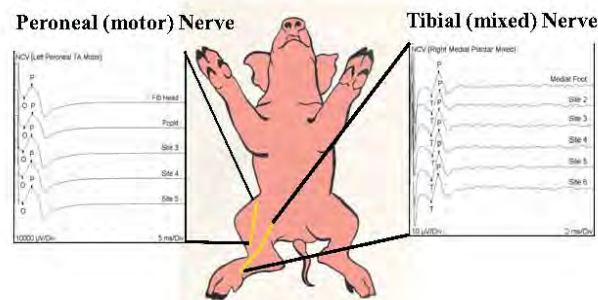
Methods: Gait Testing

Modified Tarlov Score:

- 0 - Insensate, paralyzed limb
- 1 - Able to sit
- 2 - Stands, unable to bear weight
- 3 - Walks, with gait or posture abnormality
- 4 - No gait or posture abnormality

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Methods: Nerve Conduction Studies



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Methods: Statistical Analysis

- Univariate analysis of single measures endpoints were described by one way ANOVA
- Repeated measures of nerve conduction was combined in a mixed regression model to establish a physiologic measure of recovery (PMR) to characterize the ischemic threshold of the extremity

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Results: Baseline

| Variables Means (SE) | 1 HR N=6 | 3 HR N=5 | 6 HR N=6 | 1 HR-F N=6 | 3HR-F N=6 | 6HR-F N=6 |
|-------------------------|-------------|-------------|-------------|---------------|--------------|--------------|
| Wt [kg] | 76.5 (1.2) | 76.2 (1.5) | 73.8 (2.9) | 73.7 (3.6) | 76.6 (2.6) | 77.9 (1.7) |
| MAP [mmHg] | 72 (2.6) | 69.6 (8.3) | 54.2 (6.2) | 60 (4.3) | 65.7 (4.2) | 62.7 (7.3) |
| LDH [U/L] | 297 (69) | 341 (33) | 228 (39) | 300 (58) | 275 (28) | 248 (35) |
| CK [U/L] | 1548 (918) | 1272 (431) | 1009 (266) | 807 (163) | 635 (67) | 688 (74) |
| Myoglobin [ng/mL] | 47 (11) | 38 (8) | 26 (2) | 49 (15) | 40 (7) | 46 (8) |

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Results: Baseline

| Variables Means (SE) | 1 HR N=6 | 3 HR N=5 | 6 HR N=6 | 1 HR-F N=6 | 3HR-F N=6 | 6HR-F N=6 |
|-----------------------------------|-------------|-------------|-------------|---------------|--------------|--------------|
| Tarlov Score | 4 | 4 | 4 | 4 | 4 | 4 |
| CMAP [mV] | 12.5 (0.9) | 13.3 (1.8) | 12.3 (1.5) | 9.3 (1.2) | 10.3 (0.9) | 9.8 (1.2) |
| SNAP [uV] | 14.5 (1.6) | 13.4 (1.6) | 11.0 (0.7) | 13.3 (1.2) | 14.9 (1.4) | 11.0 (1.4) |
| NCV [m/sec] | 57.8 (2.7) | 58.2 (3.2) | 60.7 (2.9) | 56.4 (3.0) | 56.8 (3.1) | 55.4 (3.0) |
| Compartment Pressure [mmHg] | 9.1 (0.7) | 10.4 (1) | 8.2 (0.9) | 8.9 (1.0) | 9.3 (1.7) | 8.7 (0.9) |

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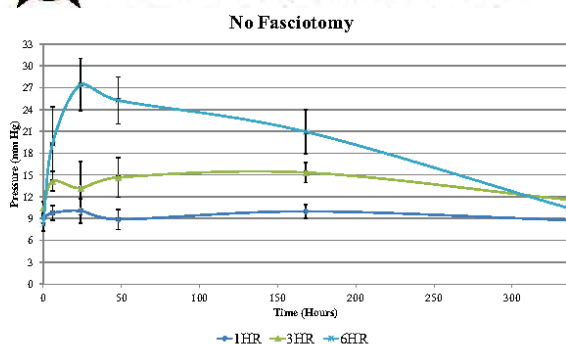
Results: Final

| Variables Means (SE) | 1 HR N=6 | 3 HR N=5 | 6 HR N=6 | p-value | 1 HR-F N=6 | 3HR-F N=6 | 6HR-F N=6 | p-value |
|-------------------------|-------------|-------------|-------------|---------|---------------|--------------|--------------|---------|
| CMAP [mV] | 10.3 (1.0) | 5.8 (1.5) | 3.2 (1.4) | <0.001 | 4.5 (0.3) | 4.9 (1.3) | 1.5 (0.7) | 0.03 |
| SNAP [uV] | 15.0 (2.1) | 8.1 (1.5) | 5.0 (0.9) | 0.04 | 11.5 (1.0) | 11.3 (1.1) | 5.1 (1.4) | 0.005 |
| AST [U/L] | 44 (6) | 45 (4) | 52 (4) | 0.65 | 50 (8) | 45 (9) | 50 (6) | 0.80 |
| Myoglobin [ng/mL] | 63 (32) | 39 (7) | 39 (6) | 0.42 | 48 (9) | 23 (7) | 21 (2) | 0.36 |
| Flows [cm/s] | 59.8 (5.1) | 68.3 (6.3) | 61.1 (6.8) | 0.08 | 64.2 (10.6) | 44.5 (7.8) | 65.1 (5.4) | 0.10 |

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Results: Compartment Pressure

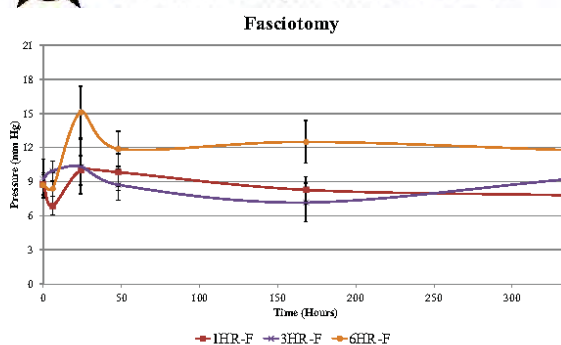
No Fasciotomy

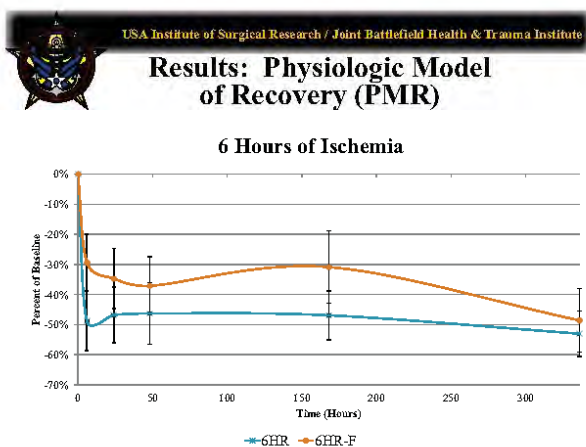
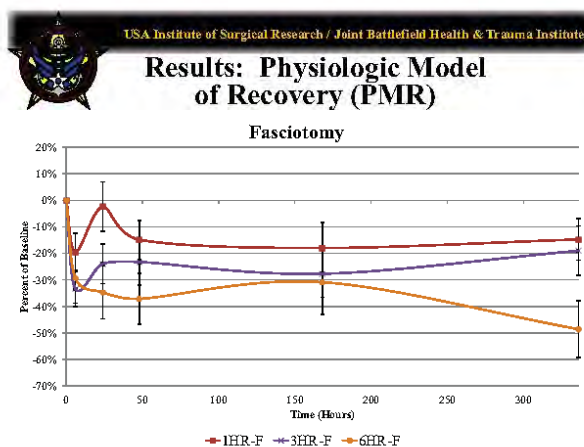
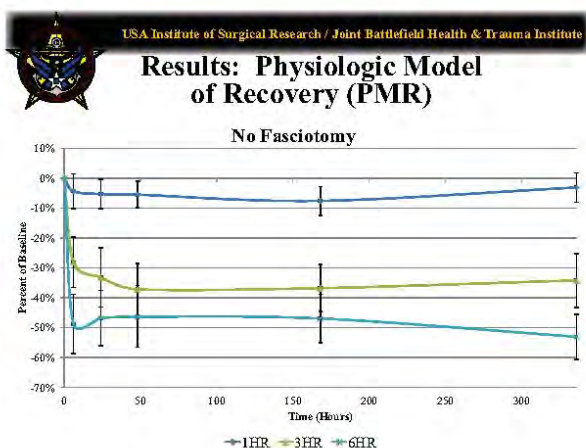
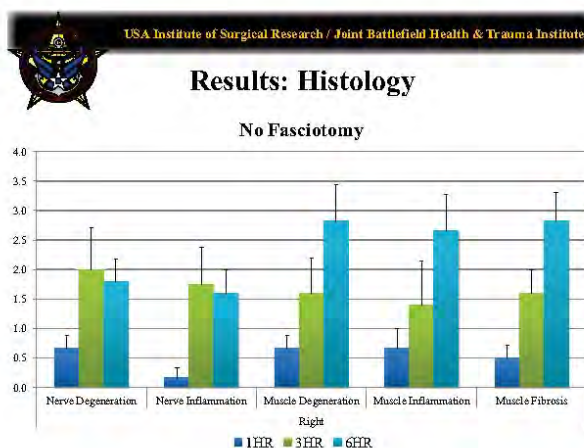


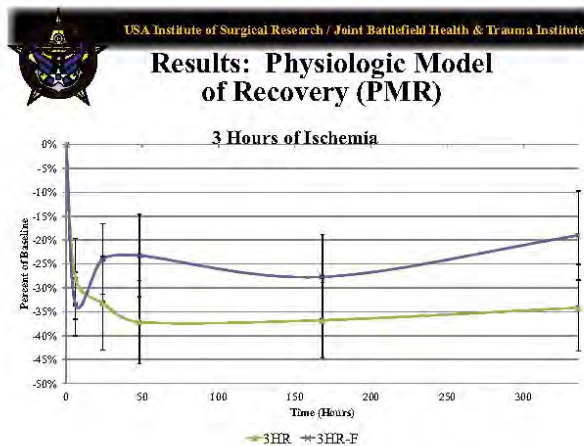
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Results: Compartment Pressure

Fasciotomy







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- ### Summary
- Fasciotomy relieved compartment pressure after 3 and 6 hours of ischemia
 - In the control group, there was a statistically significant decrement to recovery between the 1 and 6 hour ischemia groups
 - In the fasciotomy group, the 1 and 3 hour ischemia groups were found to be similar and had a significantly better recovery than 6 hours of ischemia

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- ### Conclusion
- A translatable large animal model of compartment syndrome with varying times of ischemia is achievable
 - If fasciotomy is *not* performed, the ideal time for vascular repair is less than 1 hour
 - If fasciotomy is performed, the ideal time for vascular repair is between 1 and 3 hours of ischemia



A Nursing Research System to Obtain Functional Outcomes and Provide Clinical Education Following Wartime Extremity Vascular Injury

USAISR

Capt Diane Lynd

Authors: Ivatury RA, Keltz BM, Lynd DL, Ames-Chase AC, Porras C, RasmussenTE, Feider LL

BACKGROUND: The rate of vascular injury in the wars in Iraq and Afghanistan are five times that previously reported in combat with extremity injury most common. Extremity vascular injury is associated with significant long-term morbidity and repairs requiring surveillance ensure best durability and outcome. Despite the commonality and significance of this injury pattern, current systems to ascertain patient-based outcomes and provide education are poorly developed. **OBJECTIVE:** To describe a novel system designed to contact troops in the years following extremity vascular injury to ascertain quality of life and limb outcomes and provide education on surveillance of vascular repair.

METHODS: A research team comprised of nurses with wartime experience conducted a review of the Joint Theater Trauma Registry (JTTR) identifying US troops having sustained extremity vascular injury. A medical record review was performed to confirm the presence of vascular injury and or injury repair and patient contact attempted. Informed consent was obtained and outcomes information was gathered using the Standard Form 36 (SF-36) and Short Musculoskeletal Function Assessment (SMFA). Vascular injury education was provided based on an algorithm that directs follow-up and surveillance.

Results: Extremity vascular injury was confirmed in 751 patients. Attempted contact of 189 (25%) and actual contact completed for 91(48%). Of the 91 patients contacted, 80 (88%) consented to participate, and 11(12%) either declined consent or were unresponsive. Of the 80 consented, 24 (30%) completed surveys and 56 (70%) are pending survey completion. Of the 24 respondents, 17 had salvaged limb with graft or patch or anastomosis primary repair and received education regarding the need for follow-up care with a vascular surgeon. **CONCLUSIONS:** Nursing-driven outcomes research and education are feasible following wartime injury. This method provides relevant insight into extent of recovery following injury on the battlefield and allows this information to be linked to early injury characteristics and management strategies.

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.



United States Army Institute of Surgical Research

A Collaborative Research System for Functional Outcomes Following Wartime Extremity Vascular Injury Patterns

Principal Investigator:
Todd Rasmussen, Col, USAF, MD
Deputy Commander of the Institute of Surgical Research (ISR)

Presenter: Diane Lynd, RN, MPH
Research Nurse, ISR



United States Army Institute of Surgical Research

Acknowledgements & Disclaimers

- The author(s) acknowledge Joint Theater Trauma Registry (JTTR) for providing data for this study.
- This study was conducted under a protocol reviewed and approved by the US Army Medical Research and Materiel Command Institutional Review Board and in accordance with the approved protocol.
- There are no financial disclosures



United States Army Institute of Surgical Research

Introduction

- An Air Force lead initiative, fills gap in outcomes data
 - Ability to relate acute causality care to outcomes
- Relies on professionals with multiple specialties
 - Research Nurses
 - Software development
 - Administrative Support
 - Resident and Fellows



United States Army Institute of Surgical Research

Outline

- Background
- Objectives
- Methods
- Results
- Conclusion



Background: Vascular Injury

- Blood Vessel injury common injury pattern in combat
 - Leads to significant morbidity & mortality
 - OIF/OEF vascular injury affects up to 12% of all combat wounded (White et al, 2011)
 - Varies by theater, mechanism of injury & operational tempo
- OIF/OEF/OND opportunity to develop a modern vascular registry to examine strategies in the care of casualties (Rasmussen et al, 2006)



Background: Registries

- Established at Walter Reed General Hospital in 1966 to:
 - Document & analyze blood vessel injuries in Vietnam
 - Provide long term follow-up and results
- Historical model for research and long term follow-up in military community
- Changes since Vietnam:
 - Safety equipment available to service members
 - Technology: better medical records and tracking



Objectives: Study

- The Global War on Terrorism Vascular Injury Initiative (GWOT VII) objectives are:
 - Identify the incidence of vascular injuries related to combat
 - Contact service members who sustained vascular injury
 - Determine if amputation in theatre leads to better mental or physical health scores than vascular repairs
 - Ascertain first ever patient based outcomes data following wartime vascular injury




Objectives: Presentation

- Consider ways a long-term outcomes based research method could benefit other research areas
- Present early results & survey completion from study

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Methods: Key Components

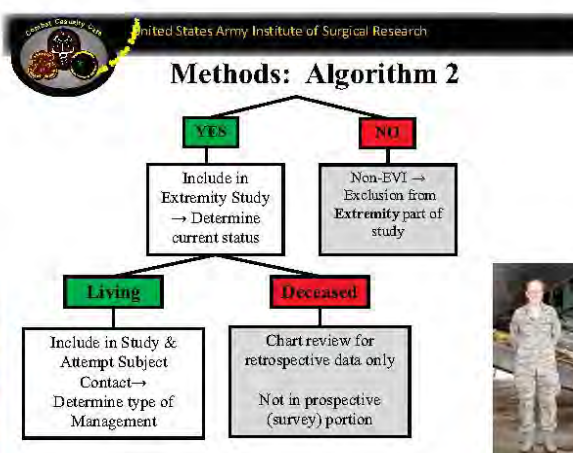
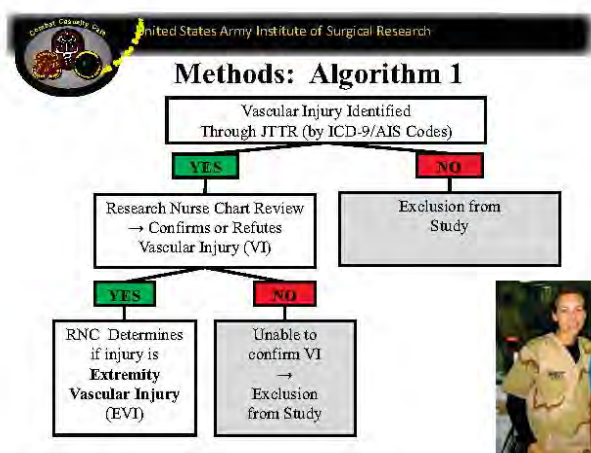
1. Review of medical records to determine specific types of repair and subject outcome; multiple sources
2. Validated surveys to collect outcomes data
 - 99 questions total
 - Demographic questions
 - Short Musculoskeletal Functional Assessment
 - SF-36v2™ Health Survey (Short-Form Health Survey)
3. Uniquely qualified research team
 - Physicians and nurses with wartime experience
4. Long-term follow-up with subjects
 - Currently on second survey cycle
 - Future follow-up

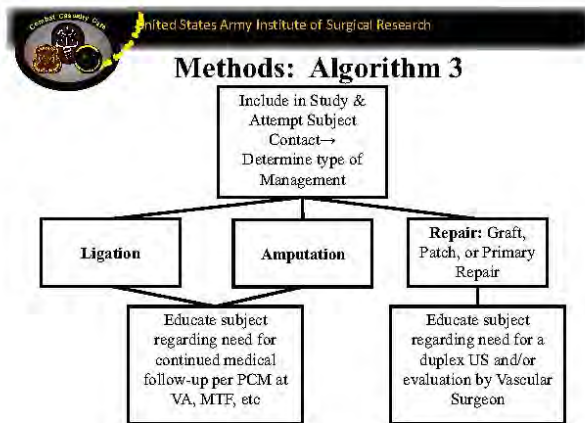


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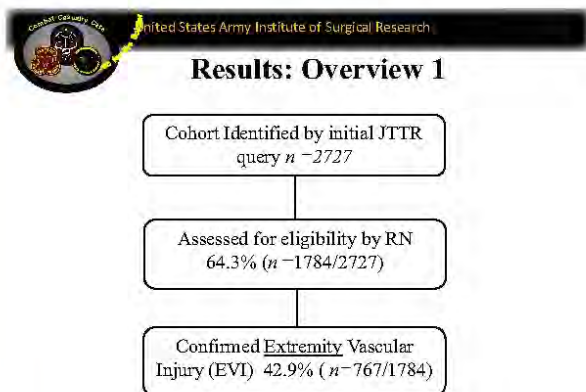
Methods: JTTR query

- Joint Theater Trauma Registry (JTTR) to identify study cohort
- Search Criteria for JTTR Query
 - Active Duty
 - BI: Battle Injury
 - Blast, penetrating & vehicle accidents
 - Vascular Injury with AIS 2-6 (no head)
 - Documented vascular injury
 - identified by ICD9 codes
 - Includes surgical procedures and Hemorrhagic control NOS
 - Operation: OIF/OEF

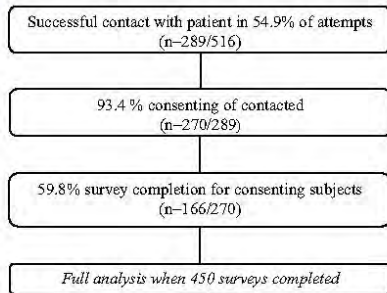





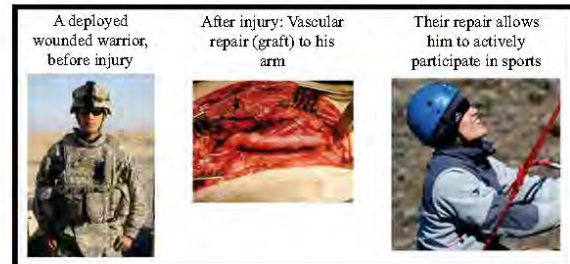
- United States Army Institute of Surgical Research
- ### Lessons Learned
- Dedicated staff needed to search multiple databases & internet
 - Review of medical records requires Protected Health Information (PHI) to link data
 - Microsoft Access is limited when you have multiple users or a large number of subjects (i.e. 2,727 subjects and 4 users)
 - Consider developing of a program tailored to specific needs early in research plan



United States Army Institute of Surgical Research
Results: Overview 2



United States Army Institute of Surgical Research
Results: Overview 3



For all figures in the following slides, n= 159

United States Army Institute of Surgical Research
Results: Contact Attempts

| Phone Contact | |
|--|--------|
| Average, phone contacts with subjects before survey completion | 1.99 |
| Median, phone contacts with subjects before survey completion | 2.00 |
| Range, phone contacts with subjects before survey completion | 1 to 6 |
| Email Contact | |
| Email only contact (i.e. AKO) | n=12 |

United States Army Institute of Surgical Research
Results: Demographics 1

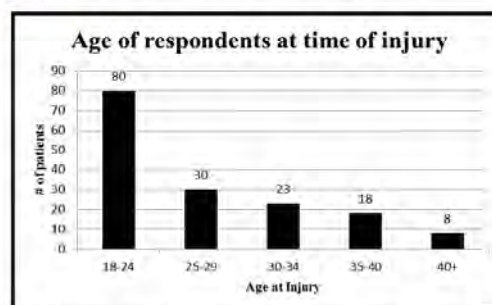
- Extracted from medical records during chart review
 - Theatre of operation
 - OIF, n=144
 - OEF, n=15
 - Gender
 - Males, 156 subjects
 - Females, 3 subjects

Results: Demographics 2



Information extracted from deployed medical record during chart review

Results: Demographics 3



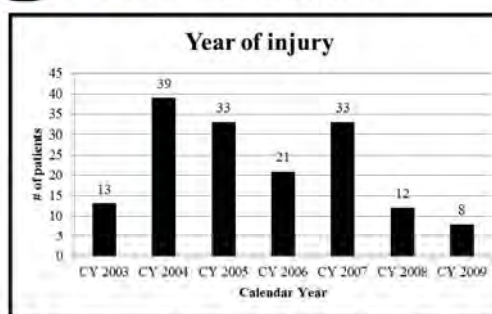
Information extracted from deployed medical record during chart review

Results: Demographics 4



Information extracted from deployed medical record during chart review

Results: Demographics 5



Information extracted from deployed medical record during chart review

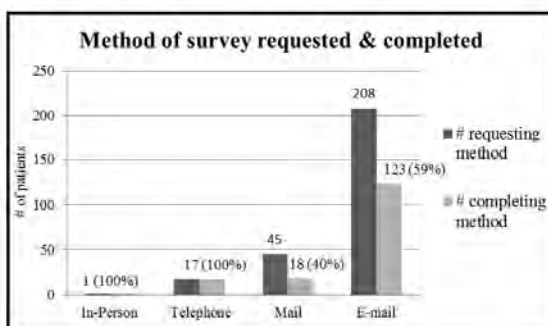
United States Army Institute of Surgical Research
Results: Demographics 6

| Months between date of injury and survey completion | |
|--|-------|
| Average, months between date of injury and survey completion | 61.94 |
| Median, months between date of injury and survey completion | 66.00 |
| Range, months between date of injury and survey completion | 19-96 |

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Results: Demographics 7



United States Army Institute of Surgical Research
Results: Demographics 8



United States Army Institute of Surgical Research
Applying this model

- Method to deliver outcomes data, not limited to vascular injury
 - Ocular, head and neck and GI researchers are employing this method
- Demonstrates evidence-based results
- High response rate to surveys, at 60%
 - Nurse follows the subject throughout the study
 - Subject-researcher relationship improves willingness to complete survey
- Loyalty and commitment of the injured



Conclusion

- Veterans from OIF/OEF with amputations and limb salvage have returned to duty, started degree programs and are actively involved in sports and recreational activities
- Long-term subject-based outcome studies are essential to ensure surgical care in theater allows for the best possible outcome for wounded warriors.



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- www.sf-36.org/tools/sf36.shtml

Major Arterial Vascular Injuries Sustained During Combat Operations: Demographics, Outcomes, and Lessons To Be Learned from Contrasts to Civilian Counterparts

Brooke Army Medical Center

Capt Nicholay Markov

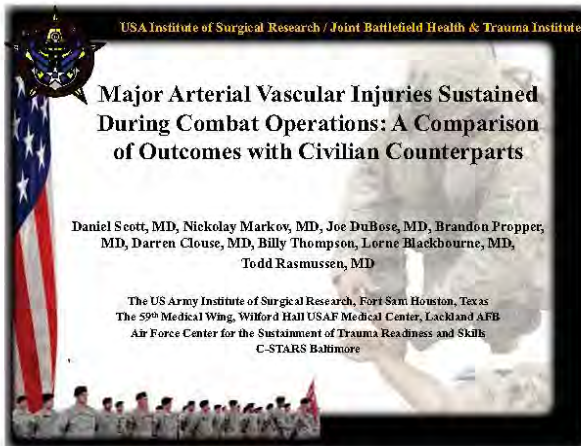
INTRODUCTION: Vascular injuries account for 12% of all combat-related injuries in recent conflicts in Iraq (OIF) and Afghanistan (OEF). We reviewed the epidemiology and outcomes of these injuries from the Joint Trauma Theater Registry (JTTR), contrasting these results with civilian counterparts from the National Trauma Databank (NTDB). **METHODS:** JTTR query identified major arterial vascular injuries (Non-compressible = axillary, subclavian/innominate, aorta, carotid, iliac; Compressible = brachial, femoral, popliteal) in coalition casualties from 2002-2006. The demographics, patterns and severity of outcomes of these injuries were evaluated and compared to civilian NTDB counterpart's age 18-35 using Propensity Score matching. **RESULTS:** JTTR identified 380 patients meeting criteria. The majority of injuries were the result of an explosion (68.7%) or GSW (28.2%). GCS was ≤ 8 in 34.3%, ISS > 15 in 44.5%, and 20.5% had hypotension (SBP < 90) on arrival to a theater hospital. Comparison to unmatched NTDB patients meeting study criteria (n = 7400) revealed that JTTR patients were more likely to have sustained arterial injury at compressible sites (55.5% vs. 38.6%, $p < 0.001$) and were more likely to have concomitant venous injury (54.5% vs. 18.4%, $p < 0.001$). Comparison of 167 propensity score matched (1:1) JTTR to NTDB counterparts revealed a significantly lower mortality rate among JTTR patients overall (4.2% vs. 12.6%, $p = 0.006$; OR 0.30 [0.13-0.74]), those with arterial injury at non-compressible sites (10.8% vs. 36.5%, $p = 0.008$; OR 0.21 [0.06-0.71] and for ISS > 15 (10.7% vs. 42.4%, $p = 0.006$; OR 0.16 [0.04-0.65]). **CONCLUSIONS:** Comparison to civilian counterparts has inherent limitations, but reveals improved survival among combat-related vascular injuries overall, for non-compressible arterial injuries and among the most severely injured. The etiology of these findings is likely multi-factorial and warrants further investigation.

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Major Arterial Vascular Injuries Sustained During Combat Operations: A Comparison of Outcomes with Civilian Counterparts

Daniel Scott, MD, Nikolay Markov, MD, Joe DuBose, MD, Brandon Propper, MD, Darren Clouse, MD, Billy Thompson, Lorne Blackburne, MD, Todd Rasmussen, MD

The US Army Institute of Surgical Research, Fort Sam Houston, Texas
The 59th Medical Wing, Wilford Hall USAF Medical Center, Lackland AFB
Air Force Center for the Sustainment of Trauma Readiness and Skills
C-STARs Baltimore



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Disclosure

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Air force or the Department of Defense

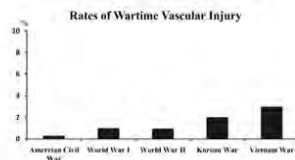
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Background

ORIGINAL ARTICLE

The Epidemiology of Vascular Injury in the Wars in Iraq and Afghanistan

Joseph M. White, MD*, Adam Stannard, MRCSEd, Gabriel E. Burkhardt, MD*, Brian J. Estridge, MD*, Lorne H. Blackburne, MD*, and Todd E. Rasmussen, MD*



(Ann Surg 2011;253:1184-1189)

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Background

The Journal of TRAUMA® Injury, Infection, and Critical Care

Injury Severity and Causes of Death From Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 Versus 2006

Joseph F. Kelly, MD, Amber E. Ritenour, MD, Daniel F. McLaughlin, MD, Karen A. Bagg, MS, Amy N. Apodaca, MS, Craig T. Mullik, MD, Lisa Pearse, MD, Mary M. Lowenick, RN, BSN, Howard R. Champion, MD, Charles E. Wade, PhD, and COL John B. Holcomb, MC

J Trauma. 2008;64:S21-S27.



Background

Table 4 Causes of Death Among Potentially Survivable Casualties

| Cause of Death* | Group 1 (n = 10) | Group 2 (n = 138) |
|----------------------------------|------------------|-------------------|
| | (% Total of PG) | (% Total of PG) |
| CNS | 12 (12) | 8 (6) |
| Head | 11 (12) | 6 (4) (p < 0.04) |
| Neck | 1 (1) | 0 (0) |
| Spinal cord | 1 (1) | 3 (2) |
| Hemorrhage | 81 (81) | 116 (83) |
| Trauma/vascular (excl) | 31 (33) | 46 (33) |
| Noncompressible (excl) | 47 (51) | 68 (49) |
| Nontrauma/vascular (excl) | 19 (20) | 29 (21) |
| Artery | 14 (15) | 14 (10) |
| Sepsis/MISOF | 2 (2) | 9 (6) |
| Total causes of death identified | 219 | 299 |



70%



Background

- Joint Theater Trauma Registry (JTTR)
 - Assess and implement quality care for those injured in Iraq and Afghanistan
- National Trauma DataBank (NTDB)
 - Descriptive information about civilian trauma patients (demographics, injury information, and outcomes)

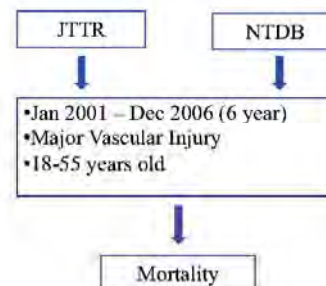


Objective

- Compare civilian and military experiences and outcomes with traumatic vascular injuries
 - Evaluation of commonality and variance between practices
 - Optimization of care for wounded warriors
 - Provide translatable lessons from combat care to civilian trauma systems



Methods



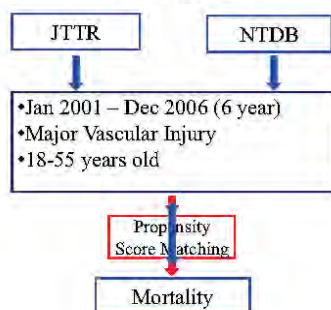
Methods: Statistical Analysis

- JTTR and NTDB variables compared
 - Means and standard errors
 - Mortality odds ratios
- Propensity Score Matching
 - Used for matching
 - Predictor variables matched to mortality calculated
 - Age, gender, first systolic blood pressure, Glasgow Coma Score, and Injury Severity Score
 - Matched subjects compared

Results: Overall (Unmatched)

| | | JTTR | NTDB | p = value |
|---------------------------------|-------------|------------|-------------|-----------|
| Number | | 380 | 7020 | N/A |
| Age (years) | | 25.7 ± 6.5 | 31.6 ± 10.1 | <0.001 |
| Men (%) | | 98.7 | 82.8 | NS |
| Injury Pattern (%) | Explosion | 68.7 | 0 | <0.001 |
| | Penetrating | 28.2 | 50.0 | <0.001 |
| | Blunt | 3.2 | 50.0 | <0.001 |
| Non-compressible hemorrhage (%) | | 26.6 | 61.4 | <0.001 |
| Mortality (%) | | 8.4 | 28.6 | <0.001 |
| Mortality Predictors (%) | GCS<8 | 34.3 | 35.8 | 0.584 |
| | ISS>15 | 44.5 | 67.9 | <0.001 |
| | SBP<90 | 20.5 | 27.3 | 0.005 |

Methods



Results: Matched

| | JTTR | NTDB | p = value | |
|------------------------|---------------|------|-----------|-------|
| Number | 167 | 167 | N/A | |
| Mortality (%) | 4.2 | 12.6 | 0.006 | |
| Subgroup Mortality (%) | NCAI | 10.8 | 36.4 | 0.008 |
| | NCAI + ISS>15 | 14.3 | 63.2 | 0.005 |

NCAI – Non-Compressible Arterial Injury
ISS – Injury Severity Scale



Discussion

- Civilian vs. Military
 - Overall reduction in mortality after major vascular injury
 - Military members 3X as likely to survive with ANY vascular injury
 - Military member twice as likely to survive with non-compressible arterial injury



Discussion



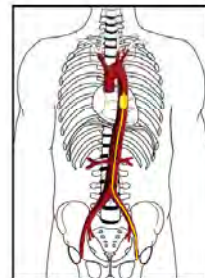
We should not rest content with the work of our predecessors, or assume that it has proved everything conclusively, on the contrary it should serve only as a stimulus to further investigation

Ambroise Paré
16th Century



Discussion: Future

- Non-Compressible Hemorrhage



Advanced Team Training for Long-Range Extracorporeal Support Transport: The San Antonio Military Adult ECLS Team experience

59 MDW

Lt Col Jeremy Cannon

BACKGROUND: Combat casualties with severe respiratory failure may require extracorporeal life support (ECLS) to permit safe long-range transport. To meet this need, a transport team trained in ECLS indications, physiology, and equipment is required. This report summarizes the training activities of the San Antonio Military Adult ECLS Team over the previous 10 months. **METHODS:** Physicians and nurses with experience in combat casualty care, advanced critical care therapies, and long-range transport were identified as potential candidate ECLS team members. Training included didactic modules on the indications for extracorporeal support, modes of support, and troubleshooting. Hands-on simulation and live tissue training reviewed circuit setup and emergency scenarios. Expert instructors for these sessions were drawn from well-established military and civilian ECLS teams.

RESULTS: To date, 7 physicians, 10 nurse specialists, and 1 clinical nurse specialist have been selected for training as candidate members of the San Antonio Military Adult ECLS Team. Of these 18 candidates, 18 (100%) have completed a didactic course, 10 (56%) have undergone simulation training, and 11 (61%) have participated in at least 1 live tissue training session. More nurse candidates have completed hands-on simulation training than physician candidates (70% vs. 43%) while fewer nurses have participated in live tissue training as compared to physicians (30% vs. 100%).

CONCLUSIONS: Establishing a team capable of long-range ECLS transport requires intensive training in cardiopulmonary physiology and ECLS equipment and techniques. Military and civilian teams experienced in neonatal, pediatric, and adult ECLS have worked over the past 10 months to provide our candidate team members the knowledge and skill to perform ECLS in garrison and during transport. Future efforts will focus on completion of simulation and live tissue training, maintenance of qualifications, and bedside experience with ECLS patients.

Advanced Team Training for Long-Range Extracorporeal Support Transport: the San Antonio Military Adult ECLS Team Experience

The opinions and assertions contained herein are the private views of the presenter and are not to be construed as official or reflecting the views of the Department of the Air Force or the Department of Defense.

I have no commercial or financial interests to disclose.

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Trauma & Acute Care Surgery
Brooke Army Medical Center
Aug 3, 2011
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210-289-7672

Adult Extracorporeal Life Support...

Doesn't make any sense...

or a REALLY bad idea.



Background

History



Technology Improvements



Clinical Developments

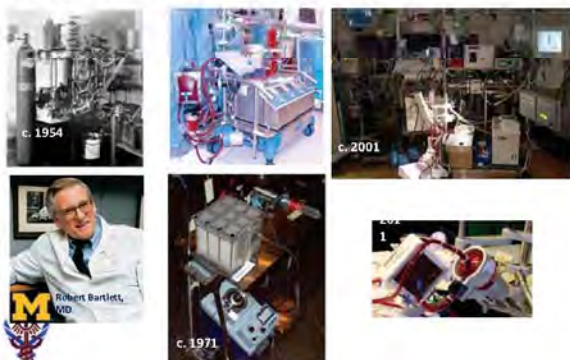


N Engl J Med 2007; 357(11):1113-20.

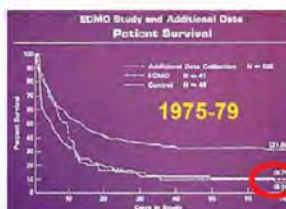
Transport ECMO for CCC



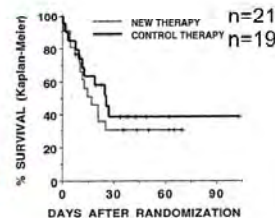
ECLS emerged from the advances made for cardiopulmonary bypass.



Adult ECLS and ECCO₂R trials showed no mortality benefit.



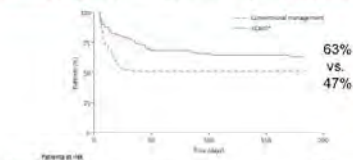
JAMA Nov 1979;242(20):2193-8.



Am J Resp CC Med 1994;149:295-305.

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peck, Miranda Muggford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Marianna M Thelani, Claire L Hibbert, Ann Truandale, Felicity Clement, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration
Lancet 2009;374:1551-63.



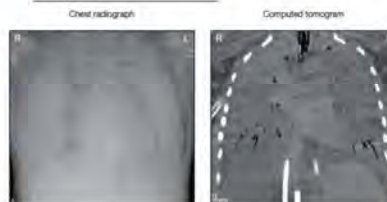
Referral to a center with the full spectrum of therapies saves lives in severe ARDS

CARING FOR THE CRITICALLY ILL PATIENT JAMA-EXPRESS

Extracorporeal Membrane Oxygenation for 2009 Influenza A(H1N1) Acute Respiratory Distress Syndrome

The Australia and New Zealand Extracorporeal Membrane Oxygenation (ANZ ECMO) Influenza Investigators*

JAMA Oct 2009;302(17).



68 on ECMO
54 alive (79%)
6 still in ICU
-->2 on ECMO
16 still in hospital

ECLS equipment HAS evolved significantly in the last decade.

**PMP Membrane = Low resistance =
Less coagulopathy**
**Centrifugal Pump = Short Circuits =
Less Inflammation**



VS.



ECLS equipment HAS evolved significantly in the last decade.

**PMP Membrane = Low resistance =
Less coagulopathy**

**Centrifugal Pump = Short Circuits =
Less Inflammation**

Single site cannulation for VV ECLS = Early Mobilization



VS



ECLS equipment HAS evolved significantly in the last decade.

PMP Membrane = Low resistance = Less coagulopathy
Centrifugal Pump = Short Circuits = Less Inflammation

Transport equipment dramatically downsized



VS.



Air Transport of Patients With Severe Lung Injury: Development and Utilization of the Acute Lung Rescue Team

Gina B. Dorlac, MD, FACP, Raymond Fang, MD, FACS, Valerie M. Pruitt, MD, Peter A. Marco, MD, FCCP, Heidi M. Stewart, RN, MSN, CCRN, Stephen L. Barnes, MD, FACS, and Warren C. Dorlac, MD, FACS

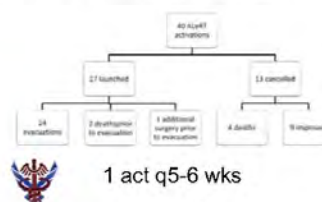
J Trauma. 2009;66:S154-71.

Closing the "Care in the Air" Capability Gap for Severe Lung Injury: The Landstuhl Acute Lung Rescue Team and Extracorporeal Lung Support

11 act : 17 mo

29 act : 39 mo

J Trauma 2011;71:S91-97

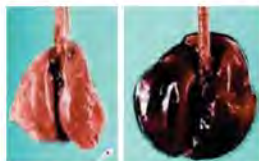


ECLS has been used for CCC transport.



What is involved in ECLS Transport?

- 1) The ECLS Team
- 2) Equipment
- 3) Candidate Patients
- 4) Transport CONOPS



The ECLS Team requires organization and training.

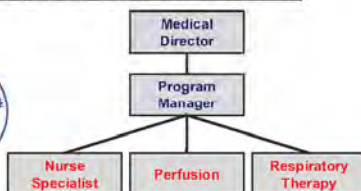


ECLS Program Minimums

- Medical Director
- Program Manager/Coordinator
- Circuit Specialists (RN, Perfusion, RT)



The ECLS Team requires organization and training.



ECLS Team Training Requirements

- Didactics
- Live Tissue Training
- Simulation
- **Transport Training**



ECLS currency requires a commitment to Year-round multi-modal education.

Didactics

- ELSO Meeting
- WHMC Course



Live Tissue Training

- Animal Lab
- Clinical Cases



Simulation



ECLS simulation allows review of critical scenarios in a safe, reproducible environment.

Pre-test/Subjective

Scenarios

- Circuit Review
- Mechanical (7)
- Physiology (6)

Participants

- Test Team
- Critique Team
- Instructors

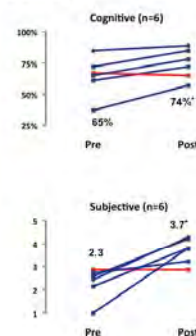
Post-test/Subjective



Simulation improves cognitive function and subjective comfort with ECLS.



1 DOC + 5 SPECS
 24 Q's + Scenario + Diagram
 Pre-programmed Sim Man



Proceedings of the 2011 AFMS Medical Research Symposium

Volume 2

Enroute Care and Expeditionary Medicine

All team members have completed 2 of 3 training modes in 1 year.

Physician Training

- 100% CLS/LTT
- 4/7 SIM
- 4/7 Deployed

Specialist Training

- 100% CLS/SIM
- 3/10 LTT
- 2/10 SIM x2

Composite Training

- CLS 100%
- LTT 61%
- SIM 78%



The future—Transport Simulation for in-house and long-range transport.



Hospital→Ambulance
Ambulance→Airframe
Airframe→Ambulance
Ambulance→Hospital



- Equipment**
Battery/Power Backup
- Supplies**
Right sized cannulas
Compatible circuit
- Logistics**
?Forklift
Police Escort
Hospital credentials
- Patient Critical Care**

Cardiothoracic Surgery

Mike Hines
Jeff McNeill
Jonathan Haft
Jerry Pratt

Trauma/CC

Mark Gunst
Alan Murdoch
Dave Zonies
Stephanie Savage
Ray Fang
Lena Napolitano
Pauline Park

Vascular Surgery

Todd Rasmussen

Surgical Oncology

Dave Smith

CCAT

Bill Beninati



Pulm/Med/CC

Jeremy Pamplin
Steve Dordak
Thomas Zanders

ISR/CC

Lee Cando
Kevin Chung
Chris White

Nephrology

Casey Cotant
Molly Tilley

Cardiology

Karin Hawkins

Emergency Medicine

Andy Muck

Neonatology

Melissa Tyree
Mark Ogino
Dan Dimberger

ECLS Coordinators

Kathryn Negaard
Heather Campbell
Bernadette Elliott
Cheryl Collicott

ISR CNS

Dave Allen

Perfusion/RT

Rex Incledon
Josh Walker
Stephen North

Education/Training

John Mechtel

Research

Roy Garcia
Deb Niemeyer
Andy Batchinsky

Collaboration across CONUS and Europe



Conclusions

- ECLS has evolved dramatically over 40 yrs.
- In respiratory failure, ECLS permits the return to lung protective settings & early mobility.
- ECLS training requirements are multimodal and transport adds an additional layer of complexity.
- The San Antonio Military Adult ECLS Transport Team is prepared to extend our support for respiratory failure patients globally.

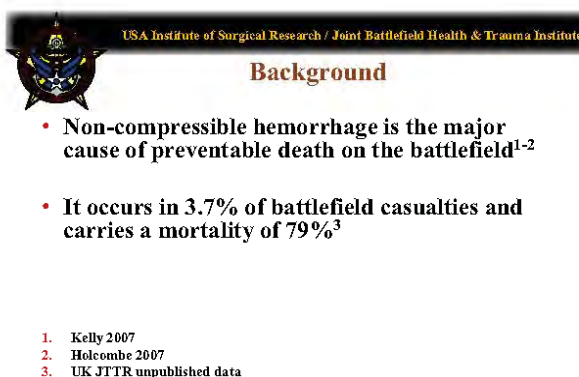
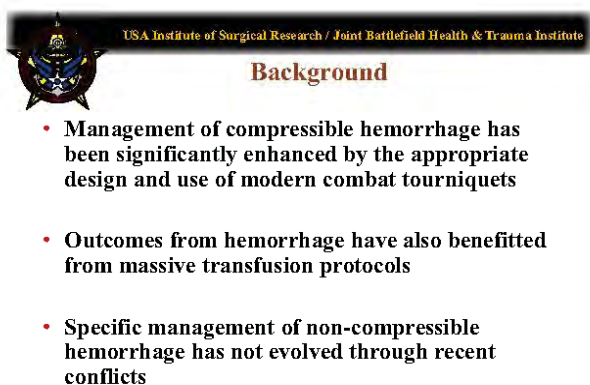
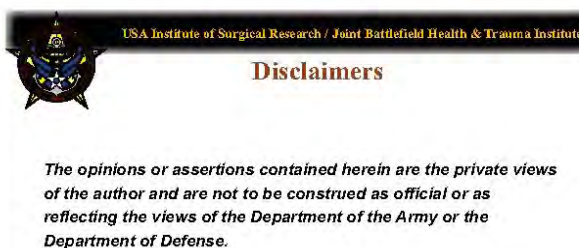
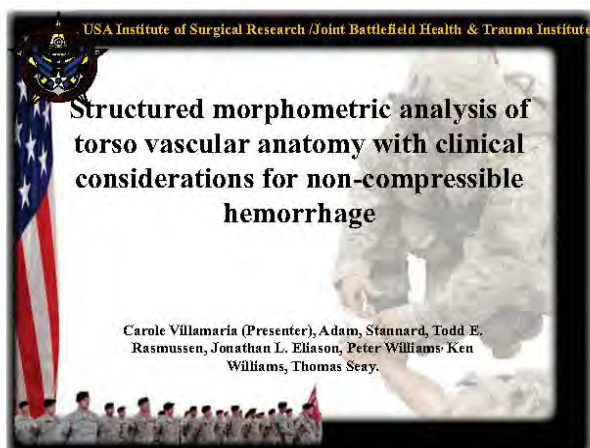


Morphometric analysis of the torso arterial tree in a male trauma population

Brooke Army Medical Center

Capt Nicholay Markov

INTRODUCTION: Management of torso hemorrhage may include resuscitative aortic occlusion to support central pressure while bleeding is temporized. The objective of this study is to characterize axial arterial anatomy of the torso in a trauma population including definition of distances and diameters correlated to an external measure of torso extent. **METHODS:** Two-hundred consecutive contrast-enhanced CT scans of the chest abdomen and pelvis performed for trauma in men (April 2009 –April 2010) were examined. One hundred eight scans qualified for analysis using Volume Viewer™ software. Centerline distances were measured between the common femoral arteries (CFA) and the origin of the primary branch vessels of the aorta additionally the aortic diameter at each point was determined. **RESULTS:** The mean age of patients was 31.5 (19-45) years. Mean distances and ranges from the left and right common femoral arteries to arterial landmarks are as follows: Left Common femoral artery to the left subclavian artery, celiac artery take off and aortic bifurcation were 537mm (472-632mm), 327mm (290-413mm) and 207mm (146-281mm) respectively. Right common femoral artery to the left subclavian artery, celiac artery take off and aortic bifurcation were 546mm (484-622mm), 335mm (274-412mm) and 201mm (165-278mm) respectively. The diameter of the thoracic aorta at the level of the left subclavian artery was 21.6 mm (16.3 mm-26.9 mm). Aortic diameters at the level of the Celiac and aortic bifurcation are 17.3 mm (12.3 mm-22.5 mm) and 14.1 mm (10 mm-18.1 mm) respectively. The diameter of the right and left external iliac arteries was 8.9 mm (5.1 mm-12.5 mm) and 8.8 mm (4.8 mm-12.8 mm) respectively. **CONCLUSION:** This study provides the first CT-based morphometric analysis of the torso arterial tree. Information from this study may facilitate the development and accurate implementation of resuscitative endovascular aortic balloon occlusion without the need for fluoroscopy.





Background



Background

- The aims of intervention are:
 1. To support perfusion of vital organs
 2. To control blood loss
- Current standard of care is thoracotomy and/or laparotomy with aortic clamping



Background

- Pneumatic Anti-Shock Garments to compress the trunk
- Lister's clamp
- Endovascular balloon occlusion as with thoracic endovascular aortic repair (TEVAR)



Background

- Endovascular aortic balloon occlusion in setting of vascular hemorrhage demonstrated positive effects:
 - Enhanced vital organ perfusion
 - Avoids detrimental physiological effects of thoracotomy/laparotomy
- Aortic balloon occlusion requires fluoroscopy and expert personnel
- Not available in austere circumstances





Aim

- Characterize torso vascular anatomy (i.e. length and diameter) relative to body habitus and in relation to an external measure
- Simple external measures unique to each individual that correlate with vascular anatomy
- Predict endovascular positioning within the torso arterial tree
- Deploy occlusive aortic balloon *without* use of fluoroscopy



Method

- 200 casualties (18-45 years old) identified from the WHMC radiological database
- Evaluated for trauma by 64 slice CT Chest/Abdomen/Pelvis
- Scans were continuous

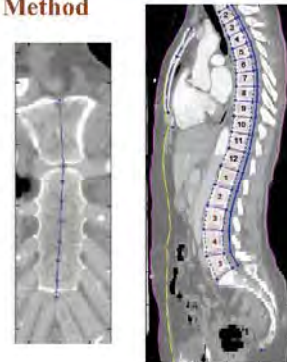


Method



Method

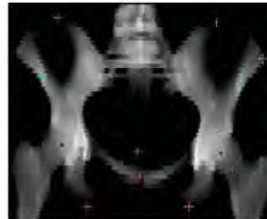
- Measure of the distance between suprasternal notch and symphysis pubis



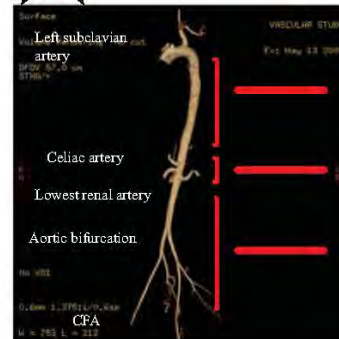


Method

- Access point over the common femoral artery at the level of the head of femur
- External measurements were correlated with torso vascular anatomy



Method

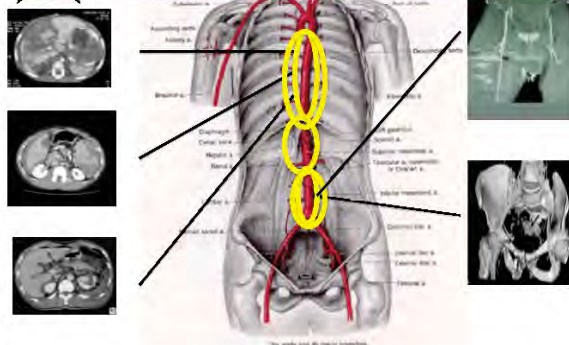


Zoning Axial Vessels

Zone I – Thoracic

Zone 2 –
Paravisceral

Zone 3– Infrarenal

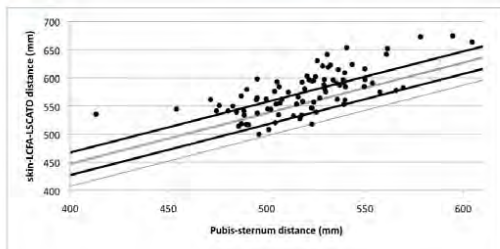


Results

| Zone | Mean Length (mm) | Min Length (mm) | Max Length (mm) | Mean Diameter (mm) | Min Diameter (mm) | Max Diameter (mm) |
|--------------------|------------------|-----------------|-----------------|--------------------|-------------------|-------------------|
| Distance RCFA - AB | 206 | 163 | 243 | 8.2 | 4.3 | 11.9 |
| Distance LCFA - AB | 196 | 146 | 241 | 8.1 | 4.6 | 10.7 |
| Zone I CA - LSA | 211.7 | 165 | 260 | 21.6 | 16.3 | 26.9 |
| Zone II LRA - CA | 32.4 | 15.5 | 54.4 | 17.3 | 12.3 | 22.5 |
| Zone III AB - LRA | 99.9 | 54.9 | 133.6 | 14.1 | 10.0 | 18.3 |



Results



Conclusion

- Detailed knowledge of torso axial vessels allows a predictable endovascular position to be ascertained from a simple external measure of torso height
- Circumvent use of fluoroscopy for aortic balloon occlusion
- Evolution in management of non-compressible hemorrhage



USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Thank You

Porcine Arterial Repair with an Extracellular Matrix Bioscaffold (CorMatrix® ECM™)

USAF / 60 MDG

Capt Brian Gavitt, Capt Matthew Chauviere, Capt Geoffrey Douglas, Capt Ryan Schutter, LtCol Daren Danielson, Col Jerry Pratt, Col(sel) Darrin Clouse, Maj Megan Steigelman, W. Douglas Boyd MD, J. Kevin Grayson DVM, PhD

Department of Surgery, David Grant Medical Center, Travis AFB, CA

Clinical Investigation Facility, David Grant Medical Center, Travis AFB, CA

Department of Surgery, UC Davis Medical Center, Sacramento, CA

OBJECTIVE: Options for immediate peripheral vascular reconstruction are limited. Autogenous vein may not be available and is difficult to procure. Prosthetic materials have significant complication profiles in contaminated wounds, limiting their use in vascular trauma. We evaluated an alternative graft material consisting of a porcine-derived extracellular matrix (ECM) bioscaffold (CorMatrix® ECM™, CorMatrix Cardiovascular, Inc., Atlanta, CA). Our study sought to establish early patency and histologic characteristics of CorMatrix® ECM™ for use in arterial repairs in swine. **METHODS:** Four crossbred swine had a 2 cm carotid arteriotomy created through a midline neck incision. The arteriotomy was repaired with a CorMatrix® ECM™ patch. Aspirin and clopidogrel were administered starting 48 hours prior to surgery and continued daily. Angiography was performed prior to euthanasia and followed by thorough necropsy and histologic evaluation. **RESULTS:** The animals had uncomplicated postoperative courses. Swine were sacrificed at one and four weeks after surgery. Arteriograms confirmed graft patency in all cases. Histologic assessment confirmed patency without evidence of thrombosis. The ECM patch was well populated with cells by one week. The implanted patch material was largely reabsorbed at 4 weeks and replaced by site-appropriate tissue consisting of organized smooth muscle, collagen, and endothelium. Neovascularization was seen within the remaining patch material.

CONCLUSION: In this pilot study, CorMatrix® ECM™ was an effective material for porcine carotid arterial repairs. ECM remodeling begins within one week and elements of normal vascular structure are seen. Further studies will be required to assess long term patency and elucidate the mechanisms of site-appropriate remodeling. **DISCLAIMER:** The animals involved in this study were procured, maintained, and used in accordance with the Laboratory Animal Welfare Act of 1966, as amended, and NIH 80 23, Guide for the Care and Use of Laboratory Animals, National Research Council. The views expressed in this material are those of the authors, and do not reflect the official policy or position of the U.S. Government, the Department of Defense or the Department of the Air Force. The work reported herein was performed under United States Air Force Surgeon General approved Clinical Investigation No. FDG20100034A. The opinions and/or assertions expressed in this article are solely those of the authors and do not reflect the official policy of the U.S. Air Force, the Department of Defense, or U.S. government.



A swine model of arterial regeneration with an acellular biologic scaffold

Capt Geoffrey Douglas, Capt Matt Chauviere, Capt Ryan Schutter, Lt Col Daren Danielson, Maj Beth Clark, Col Jerry Pratt, Col(sel) Darrin Clouse, Maj Megan Steigelman, W. Douglas Boyd MD, Mark Kashtan, J. Kevin Grayson DVM, PhD

David Grant USAF Medical Center, Travis AFB

60th Medical Group

Integrity · Service · Excellence



A better vascular graft?



- Off the shelf
- Infection resistant
- Properties of native artery
 - Resists Thrombosis
 - Endothelium
 - Compliant

60th Medical Group

Integrity · Service · Excellence



Acellular Biologic Scaffolds



- Why not just regrow the artery?
- Acellular biologic scaffolds
 - Made from multiple tissues
 - Composed of extracellular matrix
- Remodels into site appropriate tissue
 - Lures stem cells
 - Anchors stem cells



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CorMatrix® ECM™



- CorMatrix®ECM™
 - Derived from porcine small intestine
 - FDA approved for cardiovascular repairs
 - Evidence of cardiac regeneration
- Hypothesis: CorMatrix® can be used to repair an artery AND stimulate arterial regeneration



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Our Study



- Carotid arteriotomy in swine (n=4)
- Preop antiplatelet therapy
- Repaired with CorMatrix® patch
- Survived for 1 and 4 weeks

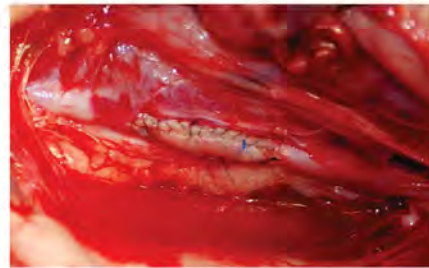


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CorMatrix In Vivo



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Results



- No major complications
- 100% patent (defined as <50% narrowing)

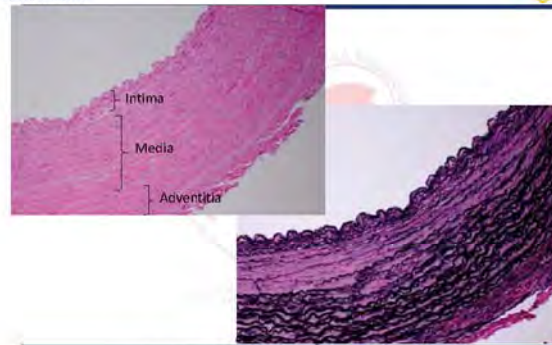


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Normal anatomy



Integrity - Service - Excellence



U.S. AIR FORCE

Conclusion



- CorMatrix® ECM™ can be used in peripheral vascular repairs
- Evidence of arterial remodeling



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Future Directions



- Longer durations
- Different materials for comparison
- Interposition grafting
- Characteristics of regeneration
- Immune reaction
- Strength / elasticity over time

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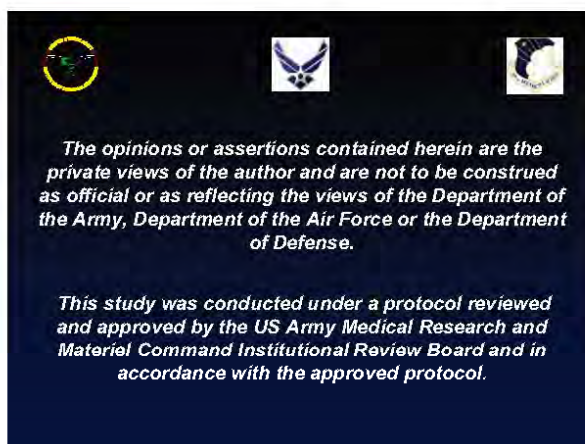
Prehospital interventions performed in a combat zone between November 2009 and December 2010

Enroute Care Research Center

Lt Col Vikhyat Bebarta, MD

OBJECTIVE: To describe prehospital interventions performed during the resuscitation of casualties in a combat zone. **METHODS:** We performed a prospective observational study recording: mechanism of injury (MOI), application of nasal/oral airway, endotracheal intubation or cricothyroidotomy, chest needle decompression, chest tube placement, chest seal application, tourniquet, use of pressure packing with/without hemostatic agent and implementation of hypotensive resuscitation. In 2010 we added: vascular access, fluid administration, hypothermia prevention and use of TCCC card. The enrolling provider determined if an intervention was not performed that was necessary (missed LSI). All data was reported in a descriptive manner. **RESULTS:** 652 patients met the inclusion criteria; mean age was 25 yrs (SD 8) and 97.4% were male. The MOI was explosion in 413 (63.3%), penetrating in 138 (21.2%) and blunt in 101 (15.5%). 39 casualties underwent an airway intervention (6.0%), with 34 (5.2%) missed LSIs; 30 underwent a chest intervention (4.6%), with 13 (2.0%) missed LSIs; 369 (13.3%) underwent a hemorrhage control intervention with 21 (3.2%) missed LSIs and 25 (3.8%) had hypotensive resuscitation applied with 8 (1.2%) missed LSIs. Vascular access was obtained in 206 of 339 casualties (60.8%) with 79 (23.3%) missed LSIs. Prehospital hypothermia prevention was employed on 244 of 339 casualties (72%) and 58 (17.1%) had their TCCC card turned in. The primary limitations include the nature of enrollment being a convenience sample and the descriptive nature of the study.

CONCLUSION: This represents the largest collection of prehospital interventions performed during the resuscitation of casualties in a combat zone.





Problem

- We do not accurately capture Life saving interventions performed in combat
- We cannot improve on performance of LSIs by medics



Objective

To describe pre-hospital interventions performed during the resuscitation of casualties in a combat zone



Methods

- We performed a prospective observational study recording:
 - Mechanism of injury (MOI)
 - Airway interventions to include:
 - Application of nasal/oral airway
 - Endotracheal intubation
 - Cricothyroidotomy



Methods

- Chest Interventions to include:
 - Chest needle decompression
 - Chest tube placement
 - Chest seal application
- Hemorrhage Interventions to include:
 - Tourniquet application
 - Use of pressure packing with/without hemostatic agent
 - Implementation of hypotensive resuscitation.



Methods

- In 2010 we added:
 - Vascular access
 - Fluid administration
 - Hypothermia prevention
 - Use of TCCC card



Methods

- The enrolling provider determined if an intervention was not performed that was necessary (missed LSI)
- All data was reported in a descriptive manner



Enrolling LSI Sites

- Included:
- Bagram AB
 - FOB Shank
 - FOB Ghazni
 - Kandahar
 - Dwyer
 - Salerno



Results

- 652 patients met inclusion criteria
- Mean age was 25 yrs (SD 8)
- 97.4% were male



Results

The MOI was:

- Explosion in 413 (63%)
- Penetrating in 138 (21%)
- Blunt in 101 (16%)



Airway

39 casualties underwent an airway intervention (6.0%)

- Nasal/Oral Airway – 10 (1.5%) casualties
- Intubation – 14 (2.2%) casualties
 - 13 ETT
 - 1 King LT
- Cricothyroidotomy – 15 (2.3%) casualties



Airway

34 (5.2%) missed LSIs were identified by the receiving facility provider



Chest Intervention

30 received chest intervention (4.6%):

- Chest needle decompression – 11 (1.7%) casualties
- Chest tube – 7 (1.1%) casualties
- Chest seal - 12 (1.8%) casualties



Chest Intervention

11 (1.7%) missed LSIs were identified by the receiving facility provider



Hemorrhage Control

369 (13.3%) underwent a hemorrhage control intervention

- Tourniquet – 95 tourniquets in 87 (13.3%) casualties
- Pressure packing (non-hemostatic agent) – 262 (40%) casualties
- Pressure packing (with hemostatic agent) – 20 (3%) casualties



Hemorrhage Control

21 (3.2%) missed LSIs were identified by the receiving facility provider



Hypotensive Resuscitation

- Hypotensive resuscitation – 25 or 3.8% of casualties
- 8 (1.2%) patients were identified by the receiving provider who should have had hypotensive resuscitation implemented in the field



Resuscitation

Vascular access was obtained in 206 of 339 casualties (60.8%)

195 IVs placed

16 IOs placed

79 (23.3%) missed LSIs were identified by the receiving facility provider



Resuscitation

152 casualties out of 339 received fluids in the pre-hospital setting:

111 received NS (73%)

30 received LR (19.7%)

16 received Colloids (10.5%)

2 Other



Hypothermia Prevention

244 out of 339 or 72%:

211 had a blanket

29 had a space blanket

6 – HPMK

2 – body bag

1 – unknown



Other

The TCCC card was turned in with 58 out of 339 casualties (17%)

147 out of 652 had prehospital vitals signs, (22.5%) casualties



Limitations

Convenience sample

Not knowing who performed the LSI

Data collection during resuscitations

Descriptive study



Conclusion

Largest study of pre-hospital interventions performed during resuscitation of combat casualties

Most common – airway, hemorrhage control, fluid resuscitation, and hypothermia treatments

Highest miss rates – fluid resuscitation, hypothermia prevention, TCCC card use, and prehospital vital signs

Factors Associated with US Military Died Of Wounds Rate in Iraq and Afghanistan

USAIR

CPT Shimul Patel

BACKGROUND: Died of wounds (DOW) rates are cited as a measure of combat casualty care effectiveness but do not account for patterns of trauma or battlefield lethality. The objective of this study is to identify injury patterns, injury severity, and mechanism of injuries that prevail in months of higher DOW rates.

Methods: Highest (HDOW) and lowest (LDOW) monthly DOW rates from 2004-2008 were identified from Department of Defense casualty databases and used to direct a search of the Joint Theater Trauma Registry. Casualties from HDOW and LDOW were combined into cohorts and injury data analyzed and compared.


RESULTS: HDOW rates were 13.4%, 11.6% and 12.8% [mean=12.6%]; LDOW rates were 1.3%, 2.0% and 2.7% [mean=2.0%] ($p < .0001$). HDOW (n=541) and LDOW (n=349) groups sustained 1,154 wounds (head-24%, chest-12%, abdomen-10%, extremities-37%). Overall injury severity score (ISS) was greater in HDOW than LDOW (11.1 ± 0.53 vs. 9.4 ± 0.58 ; $p = 0.03$), as were casualties with ISS > 25 (HDOW: 12% vs. LDOW: 7.7%; $p = .04$). Excluding minor injuries (AIS=1), HDOW had a greater percentage of chest cell injuries than LDOW (16.5% vs. 11.2%, $p = .03$). Improvised explosive devices were more common causes of injury in HDOW (58.7% vs. 49.7%; $p = 0.007$) which also had a greater proportion of Marine Corps service affiliation casualties ($p = 0.02$).

CONCLUSIONS: This study provides novel data demonstrating variations in died of wounds rates. Discernable differences in injury severity and wounding patterns are associated with large differences in DOW rates. Fluctuations in DOW rates may be more a reflection of enemy activity than a gauge of combat casualty care.

USA Institute of Surgical Research /Joint Battlefield Health & Trauma Institute

**Factors Associated With
Military Died of Wounds
Rates in Iraq and Afghanistan**

**Jonathan J. Morrison (Presenter), Shim Patel,
Adam Stannard, Mark J. Midwinter, Todd E.
Rasmussen**



USA Institute of Surgical Research / Julian Battelfield Health & Trauma Institute

Disclaimer

The viewpoints expressed in this manuscript are those of the authors and do not reflect the official position of the United States Department of Defense or the United Kingdom's Defence Medical Service

Background

- US and UK military have been engaged in almost 10 years of warfare
- Major advances in Combat Casualty Care
- What is the major morbid injury pattern?

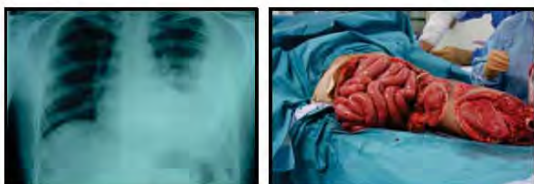
The graph displays two data series over a six-year period from 2004 to 2009. The y-axis represents the percentage, ranging from 0 to 20. The x-axis represents the years. The red line, labeled 'Killed in action', starts at approximately 14% in 2004, peaks at about 15% in 2005, and then gradually declines to 15.54% by 2009. The teal line, labeled 'Died of wounds', starts at approximately 2% in 2004 and remains relatively stable, ending at 5.38% in 2009.

| Year | Killed in action (%) | Died of wounds (%) |
|------|----------------------|--------------------|
| 2004 | ~14 | ~2 |
| 2005 | ~15 | ~2.5 |
| 2006 | ~14.5 | ~3 |
| 2007 | ~14.8 | ~3.5 |
| 2008 | ~15.2 | ~4 |
| 2009 | 15.54 | 5.38 |

[illegible]

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

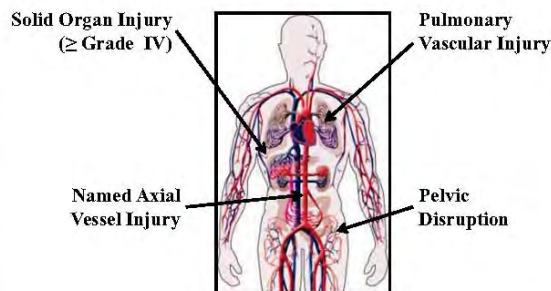
What does this mean clinically?



Vascular Disruption in the Torso Remain the Leading Cause of Potentially Preventable Death on the Battlefield

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

So what is Non-Compressible Torso Hemorrhage?



USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Epidemiology of UK NCTH

UK JTTR: 2001 to 2011

UK JTTR: 2001 to 2011
All UK Combat Wounded

- KIA: 375
- DOW: 64
- WIA: 1374

Casualty Fatality Rate: 24.2%

UK JTTR: 2001 to 2011
All UK NCTH

- KIA: 173
- DOW: 21
- WIA: 40

Casualty Fatality Rate: 82.9%

USA Institute of Surgical Research / Joint Battlefield Health & Trauma Institute

Demographic and Injury Score Data

| | KIA | DOW | WIA | p value |
|---------------------|------------|------------|------------|---------|
| Number | 173 | 21 | 40 | |
| Male (%) | 170 (98%) | 21 (100%) | 40 (100%) | 0.488 |
| Age ± SD | 26.1 ± 6.3 | 25.1 ± 6.1 | 25.3 ± 6.0 | 0.630 |
| Mechanism of Injury | | | | |
| Blast | 131 (76%) | 16 (76%) | 31 (78%) | 0.972 |
| GSW | 42 (24%) | 5 (24%) | 9 (22%) | |
| NISS ± SD | 71 ± 9 | 62 ± 13 | 42 ± 17 | < 0.001 |
| ISS ± SD | 65 ± 16 | 49 ± 17 | 31 ± 11 | < 0.001 |

Distribution of Vascular Injury

| | KIA | DOW | WIA | p value |
|-----------|-------------|------------|------------|---------|
| n | 173 | 21 | 40 | |
| Cardiac | 37 (21.4%) | 1 (4.8%) | 0 | 0.001 |
| Arterial | 109 (63.0%) | 6 (28.6%) | 7 (17.5%) | < 0.001 |
| Venous | 47 (27.2%) | 6 (28.6%) | 4 (10.0%) | 0.067 |
| Pulmonary | 32 (18.5%) | 2 (9.5%) | 4 (10.0%) | 0.288 |
| Hepatic | 45 (26.0%) | 4 (19.0%) | 8 (20.0%) | 0.609 |
| Renal | 30 (17.3%) | 2 (9.5%) | 4 (10.0%) | 0.376 |
| Splenic | 27 (15.6%) | 0 | 8 (20.0%) | 0.103 |
| Pelvic | 68 (39.3%) | 14 (66.7%) | 19 (47.5%) | 0.048 |

Who is bleeding?



Improvised Explosive Device
Multiple Frag Injuries
P: 105
BP: 110/70



GSW Chest
No Central Pulse
P: 140 (PEA Rhythm)
BP: 0/0

Decided yet?



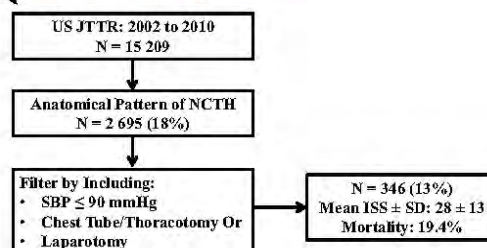
Stable for CT Scan
Single Frag in Liver
Successful Conservative
Management



"Right Turn Resus"
Maximal Surgical Exposure
Damage Control Surgery
Right Abdomen-ectomy

We need to include a Physiological and Procedural Filter to our definition of NCTH

The US Experience



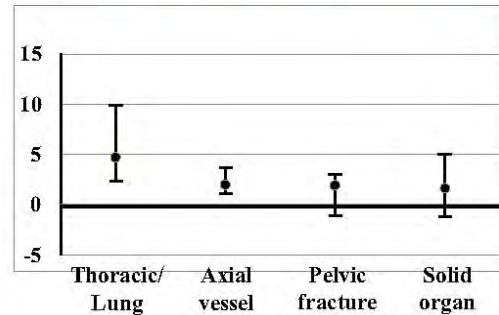


Anatomical Injury Pattern

| Injury | Incidence | Mortality | P Value |
|--------------|-------------|-------------|---------|
| Kidney | 98 (5.96%) | 17 (17.4%) | 0.409 |
| Liver | 121 (7.36%) | 20 (16.5%) | 0.248 |
| Lung | 609 (37.0%) | 145 (23.8%) | 0.014 |
| Pelvis | 189 (11.5%) | 24 (12.7%) | 0.004 |
| Spleen | 187 (11.4%) | 23 (12.3%) | 0.003 |
| Torso Vessel | 440 (26.8%) | 110 (25.0%) | 0.008 |



ISS Adjusted Odds Ratio for Mortality



Distribution of Patients Killed in Action

| Injury | Incidence |
|---------------|------------|
| Thorax | 1707 (31%) |
| Liver | 1065 (19%) |
| Spleen | 877 (15%) |
| Kidney | 621 (11%) |
| Pelvis | 536 (10%) |
| Axial Vessels | 1107 (20%) |

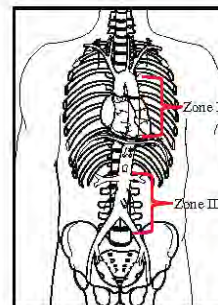
Total KIA for same time period:
• N = 5 978

Percent with NCTH:
• 92%

Data Source: AFME, Fort Dietrich & Dover AFB
Thanks to Col B Eastridge



Future Aims: Resuscitative Aortic Balloon Occlusion



Required in NCTH:
• Zone I Occlusion: 45%
• Zone III Occlusion: 55%





Summary

- Non-Compressible Torso Hemorrhage can be characterized into 4 anatomical zones
- A significant proportion of both KIA and DOW are a result of Torso Vascular Disruption in these zones
- Clinically most meaningful when a physiological or procedural filter added
- This cohort forms the basis of a future study group to improve the management of Non-Compressible Torso Hemorrhage



Remember this Patient?



6 Months Later....



Questions please

Critical Care Air Transport Team (CCATT) short term outcomes of casualties with spinal fractures moved with the Vacuum Spine Board between 2009 and 2010

59 MDW

Lt Col Vikhyat Bebarta, MD

OBJECTIVE: To describe the outcome of patients managed by CCATT with the Vacuum Spine Board (VSB) to stabilize unstable spine fractures between July 2009 and June 2010. **METHODS:** We performed a retrospective chart review evaluating short term events/outcomes of casualties transported on the VSB by CCATT. Complications and the Injury Severity Score (ISS) were obtained from the Joint Theater Trauma Registry (JTTR). All data was reported in a descriptive manner. **RESULTS:** 73 patients met the inclusion criteria, resulting in 107 patient moves. The MOI was explosion in 48 (65.8%), blunt in 22 (30.1%) and penetrating in 3 (4.1%). The mean ISS was 23.5 (SD 13.4). 64 patients were ventilated (59.8%), 10 received vasoactive medications (9.4%), and 13 received blood products (12.2%). Regarding complications: 10 had skin breakdown associated with the VSB (9.3%) and there were 2 cases of neurological deterioration which were attributed to progression of the original neurological insult (1.9%). There were 3 episodes of transient desaturation (2.8%) and 13 of transient hypotension (12.2%). We did not encounter any deaths, loss of airway or chest tubes. The primary limitations include the retrospective and descriptive nature of the study as well as the small number of casualties studied.

CONCLUSION: The VSB was successfully used to stabilize spine injuries during transport. We did note a skin breakdown rate of 9.3%. A risk/benefit assessment must be performed before deciding to use the VSB to transport casualties with spine injuries.



Develop America's Medical Airmen Today ... for Tomorrow



Develop America's Medical Airmen Today ... for Tomorrow



**Critical Care Air Transport Team (CCATT)
short term outcomes of casualties with
spinal fractures moved with the Vacuum
Spine Board between 2009 and 2010**



- Lt Col Julio Lairet, DO (PI)
- Col James King, MD
- Col Randall Mc Cafferty, MD
- Lt Col Vikhyat Bebartia, MD
- MAJ Kimberly Lairet, MD
- Maj Adam Balls, MD
- Joanne Minnick MSN, RN
- Pedro Torres BSN, RN

Providing Great Care...Building Warrior Medics

Providing Great Care...Building Warrior Medics



Objective

Develop America's Medical Airmen Today ... for Tomorrow

The purpose of this study is to describe the outcome of patients managed by USAF CCATT with the Vacuum Spine Board (VSB) to stabilize unstable spine fractures deployed in support of Operation Iraqi Freedom and Operation Enduring Freedom between July 2009 and June 2010.

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Methods

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- We performed a retrospective chart review of available records of patients who were transported by USAF CCATT on the VSB between July 1, 2009 and June 30, 2010. A standardized abstraction form was used.
- A search of the Joint Theater Trauma Registry (JTTR) was also carried out for reported complications and the Injury Severity Score (ISS) of the included patients.

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Results



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- A total of 73 patients met inclusion criteria, resulting in a total of 107 patient moves on the VSB.
- Seven patients (9.6%) had a cervical injury, 59 (80.8%) had a thoracic/lumbar injury and 7 (9.6%) suffered both a cervical and a thoracic/lumbar injury.

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Results



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- The mean age was 28.9 years (SD 8.3) and 95.9% were male.
- The mechanism of injury was explosion in 48 (65.8%), blunt in 22 (30.1%) and penetrating in 3 (4.1%).
- The mean ISS was 23.5 (SD 13.4).

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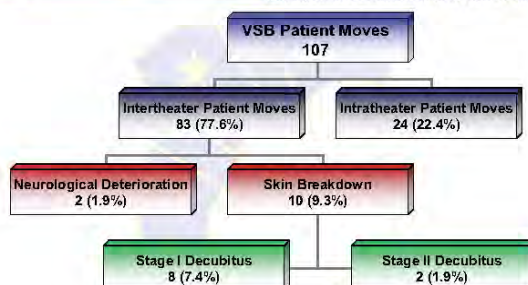
Develop America's Medical Airmen Today ... for Tomorrow

- When evaluating the treatment received during transport:
- 102 of the patient moves were on oxygen therapy (95.3%).
 - 64 were on the ventilator (59.8%).
 - 10 received vasoactive medications (9.4%).
 - 13 received blood products during the flight (12.2%).

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Short Term Events



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- 3 episodes of transient desaturation (2.8%).
- 13 episodes of transient hypotension (12.2%).
- We did not encounter any deaths, loss of airway or chest tubes during transport.

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Conclusion



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The VSB was successfully used to stabilize spinal injuries during transport. We did note a skin breakdown rate of 9.3%. Caution should be taken when considering patients for transport with ongoing neurological compression. A risk/benefit assessment must be performed before deciding to use the VSB to transport these casualties.

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Questions

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Continuous Noninvasive monitoring and the Development of Predictive Triage Indices for Outcome Following Trauma

711 HPW/USAFSAM-ETS

Dr. Colin Mackenzie

BACKGROUND: Expeditionary military triage uses basic vital signs of mental state, heart rate, and perfusion pulse pressure. Technological progress allows collection of increasing amounts of patient physiologic data that may be used to provide continuous monitoring of triage parameters. **HYPOTHESIS:** Continuous noninvasive vital signs data collected in the first hour of trauma patient resuscitation predict resuscitation requirements and identify necessity for major life saving interventions (LSIs) and 48-hr patient outcomes. Critically abnormal values ("No-Fly" decision-makers/triage tool) can be determined for several different variables derived from the photoplethysmographic (PPG) waveform and from absolute values of pulse oximetry data for injured patients by application of signal processing. **SPECIFIC AIMS AND STUDY DESIGN:** Employ continuous noninvasive vital signs data (pulse oximetry, blood pressure, electrocardiogram, and respiration) collected in trauma patients during their initial 1 hr of resuscitation after admission and assess sensitivity, specificity, and predictive value in predicting LSIs within 24 hr of admission. Calculate surrogate measures of perfusion (perfusion index, pulsatility, variability, pleth variability index, and O2 delivery index) and derive trends and absolute values of total hemoglobin [Hb] from PPG waveforms. Compare bleeding diagnoses, shock, and fluid resuscitation needs identified by these surrogate values to predictions obtained from invasive measures of [Hb], lactate, acid-base status, and O2 delivery. Compare the outcomes at 48 hr with predicted outcomes obtained from analyses of pulse oximeter and other vital signs signals, injury severity score, and revised trauma score predictions of outcome. Compare analyses based on trends of vital signs data versus those based on analyses of continuous waveforms.



Integrity ★ Service ★ Excellence

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Continuous Noninvasive Monitoring and the Development of Predictive Triage Indices for Outcome Following Trauma

Colin Mackenzie (PI),
Joseph DuBose (USAF PI),
Tom Grissom, Matt Lissauer,
Jay Menaker, Peter Hu,
John Hess, Tom Scalea

USAF Award # FA8850-11-2-6D01



1



Triage



- Civilian triage net error 65%⁽¹⁾; cost \$10B⁽²⁾
- Risk of death 25% lower in Trauma Center⁽³⁾
- Trauma triage criteria: anatomic, physiologic, and mechanism of injury (MOI)
- Paramedic judgment unreliable⁽⁴⁾
- Triage scores: Revised Trauma Score; Circulation, Respiration, Abdomen, Motor, and Speech (CRAMS); shock index \pm MOI
- Trauma and Injury Severity Score (TRISS) limitation for early triage
- Who is the significantly injured patient?

1. Mackenzie RC. History of trauma field triage development and the American College of Surgeons Criteria, Prehospital Emergency Care 2006; 10(5):287-94.
2. Mackenzie CP, et al. Automatic prehospital vital signs waveform and trend data capture fills quality management, triage and outcome prediction gaps. AMIA Ann Symp Proc 2006; 2006:3-10-22.
3. Mackenzie EJ, et al. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med 2006; 354(4):366-76.
4. Mulholland SA, et al. Is paramedic judgement useful in prehospital trauma triage? Injury 2005; 36(1):1298-305.

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2



Uncertainties in Resuscitation



- Unclear whether single or combination of vital signs (VS) is best at patient outcome prediction
- Confusion between real VS and field/resuscitation artifact
- Change, speed of change, amount of abnormal VS, trend in VS, and combinations influence on outcome prediction unknown
- No field/resuscitation real-time usable predictor; weighting coefficient for TRISS not available in field/during resuscitation
- Validation lacking of shock index, CRAMS, prehospital index, etc.
- Markers of hypoperfusion such as lactate and base deficit useful to identify high risk patients.....are there noninvasive alternatives?

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3



What's the Problem?



- **Background:** Expeditionary Trauma Medicine occurs in military field environments, often in stressful situations where decisions about potentially life threatening injuries need to be made under **uncertainty and time pressure, with inadequate information and finite resources, in adverse conditions.**
- **Civilian Trauma Team** performs multiple, simultaneous, time-critical functions, with inadequate information and ambiguous symptoms and signs.
- **Preventable mortality is greatest in 1st 30 min of trauma patient resuscitation, during which a critical decision is made every 72 s.⁽¹⁾**

1. Fitzgerald M, et al. Trauma resuscitation errors and computer-assisted decision support. Arch Surg. 2011; 146(2):18-25.

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4



What's the Idea Behind this Project?



The idea behind this project is to identify, test, and validate software modifications to an existing vital signs monitor so that it may better meet the "ideal" design characteristics of an **expeditionary device** having

1. **Accuracy:** (high sensitivity and specificity), minimizing false positives and negatives
2. **Prediction and trending of events actionable with intervention:** including hypoxemia, hemorrhagic shock, need for blood transfusion, chest decompression, airway management and other life-saving interventions (LSIs), and abdominal surgery to control hemorrhage
3. **Usability** across the echelons of trauma care, with different providers and environments
4. **Easy start,** with no calibration, minimal warm-up, limited maintenance required, and limited operator training
5. **Overall status of multiple physiological systems** vital to survival from trauma, with several alternative potential sensor monitoring sites

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5



What's New about Pulse Oximetry?



Emerging pulse oximetry technologies now provide the ability to **continuously** monitor

1. **Hemoglobin concentration (Hb)** as a marker for hemorrhage
2. **Oxygen saturation (SpO₂)** to identify hypoxemia
3. **Photoplethysmographic (PPG)** waveforms to permit calculation of a **peripheral perfusion index (PI)** that serves as a marker for hypoperfusion by subtraction of pulsatile from nonpulsatile oximetry signals
4. **Pleth variability index (PVI)** to assess volume status
5. **Oxygen transport index** (a combination with Hb, SpO₂, and PPG waveform analyses)
6. **Carboxyhemoglobin (COHb)** as a tool to **detect exposure** to in-flight carbon monoxide for both casualties and flight crew
7. **Methemoglobinemia (MetHb)** to detect exposure to burning plastics by real-time co-oximetry
8. **Respiratory rate,** by acoustic and **respiratory-induced variation PPG** signal processing

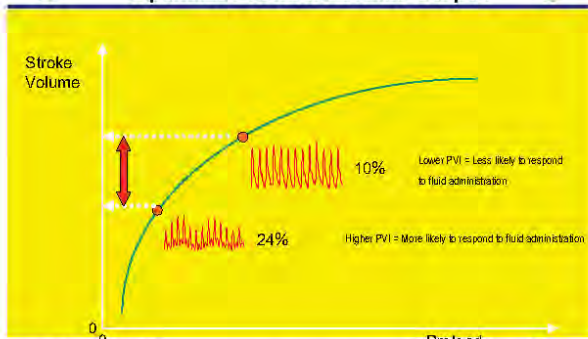
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6



Pleth Variability Index to Help Clinicians Optimize Preload/Cardiac Output



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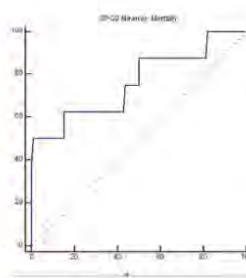
7



Pulse Oximeter Signal Predictions



Woodford et al. Continuously recorded SpO₂ and pulse rate during pre-hospital transport outperform initial measurement in prediction of mortality after trauma. J Trauma (submitted)



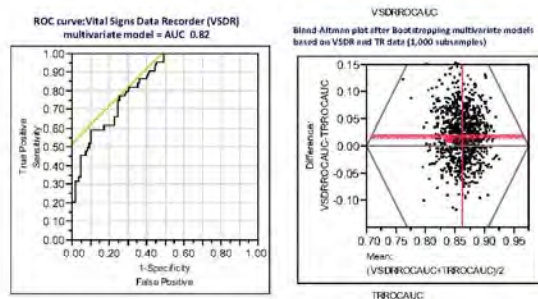
- Prediction powers measured by area under the curve (AUC) for **dose-heart rate (HR)** (0.733-0.824, $p < 0.0002-0.018$) and **dose-SpO₂** (0.766-0.847, $p < 0.0001-0.005$) were best predictors vs. trauma registry (TR)-HR (0.60, $p < 0.19$) and TR-SpO₂ (0.591, $p < 0.20$).
- **Dose-HR > 110 bpm and dose-SpO₂ < 90% at 15 min** were best predictors of mortality vs. dose-HR > 120 bpm and dose-SpO₂ < 95% at 5/10/15 min.
- Receiver-operator curve (ROC) analysis yielded an AUC of 0.76 ... meaning **SpO₂ analysis would correctly identify patient mortality in a random pair of patients who survived and did not survive 76% of the time.**
- The SpO₂ single point measurement for the TR data only did this 59% of the time, and this was significantly different and less accurate.

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8

Peaks of HR and Lowest Values of Systolic Blood Pressure and SpO2 Increase Odds of Identifying LSI vs. TR Data⁽¹⁾



1. Sen A, et al. Peeking the pre-hospital vital signs blind-spot: continuous vital signs acquisition identifies more abnormalities and changes TRES scores. Injury (submitted).

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AFRL

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Forrest, et al. Trauma resuscitation errors and computer assisted decision support. Arch Surg. 2011;146:727-25.

Reducing Errors in Acute Trauma Resuscitation

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AFRL

10

iFluidics

- Rapid, low-volume diagnostics
- Facilitated by novel microfluidics technologies
- Electrode-embedded plates generate electric fields to control each reaction step
- ELISA in <20 min in 5 µL
- First target: Biomarkers of acute kidney injury



Control over mixing for fast reactions facilitates rapid ELISA

W. C. Liu, M. H. H. Liu, J. Liu, S. J. Liu, P. H. Liu, C. Liu



Separation of particles over electrodes (RNA-red, DNA-blue)

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11

Project Tasks

- Task 1:** Identify signal processing tools to extract real underlying vital signs waveforms contaminated with motion and other artifacts. Software and algorithms developed will be tested iteratively against an **existing library** of over 1,000 trauma patient vital signs signals collected continuously during air transport [200 patient vital signs dataset collected with Propaq® Encore field monitors (Welch Allyn, Skaneateles Falls, NY)] and the first hour of resuscitation [800 patient vital signs datasets collected with GE/Marquette in-hospital monitors (GE Healthcare, Waukesha, WI) in Shock Trauma Center].
- The algorithmic predictions of 48-h outcomes will be compared, after signal processing has identified reliable signals, to the TR data to determine the sensitivity, specificity, and positive predictive value of the existing physiological dataset using this decision support tool.

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Task 1: Purpose and Product



- **The purpose of Task 1 is to predict the need for blood** within 6 h and massive transfusion within 24 h using noninvasive vital signs data and to determine the best candidate algorithmic approaches.
- **The product of Task 1** will be a selection of optimal candidate algorithms with best performance for predicting the need for transfusion and other LSIs for testing in Task 2.

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Project Task 2: New Data



- **Task 2:** A new set of 200 patient vital signs data will be acquired using the Masimo pulse oximeter (Masimo Corp., Irvine, CA) including PPG waveforms providing Hb, PVI, PI, and O2 delivery index. GE/Marquette vital signs will be simultaneously collected.
- These new data will be worked on off-line to determine features of PPG waveform and other vital signs in predicting resuscitation interventions such as airway management, chest tube insertion, blood vs. crystalloid resuscitation, and identification of intraabdominal bleeding with inclusion of additional data such as Hb and derived perfusion indices available with the Masimo.

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Task 2: Purpose and Product



- **The purpose of Task 2 is to predict the ABCs** (airway, breathing, circulation) of resuscitation from analysis of pulse oximeter PPG and other vital signs signals. The prediction algorithms will be tested, including PPG waveforms and their derived variables, before and after algorithms have been modified by systematically changing parameters to maximize predictions while minimizing false positives.
- **The product of Task 2** will be features of PPG waveforms and other vital signs identifying the need for the ABCs and other LSI resuscitation interventions.

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Project Task 3: Purpose and Initial Development



- **Task 3:** Testing the PPG algorithmic prediction of blood transfusion, LSIs, and 48-h outcome will be validated in live clinical settings. **The purpose of Task 3 is to provide "ground truth" measures of prediction performance** and potential impact on clinical practice.
- During **initial development Task 3**, the decision support system will be displayed to the clinicians (including U.S. Air Force (USAF) personnel with combat experience) to obtain questionnaire evaluation feedback as different approaches are tested.

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88-174 1063



Questions?



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Efficacy and Safety of Frozen Blood for Transfusion in Trauma Patients, A Multicenter Trial

711 HPW/USAFSAM-ETS

Ms. Samantha Underwood

BACKGROUND: Blood transfusion is one of the most commonly utilized life saving therapies in combat casualty care. Blood stored up to 42 days develops a “storage lesion” that may impair organ perfusion. Transfusion is associated with increases in multiorgan failure and mortality. Our laboratory has shown that older blood (ORBC) causes decreased tissue oxygenation (StO₂). Cryopreserved blood (FRBC) is prepared from 2- to 6-day-old blood and allows for longer storage periods, and the process of deglycerolizing and washing FRBC after thawing appears to remove cells with abnormal morphology and pro-inflammatory mediators. The effects of FRBC on perfusion, biochemical changes, inflammatory changes, and clinical outcomes in recipients have not been studied. **HYPOTHESIS:** We hypothesize that transfusion of FRBC will be superior to transfusion of ORBC with respect to physiologic, biochemical, and clinical parameters but will not be inferior to transfusion of younger red blood cells (YRBC) with respect to the same parameters. **STUDY DESIGN:** We will prospectively study 288 trauma patients requiring a blood transfusion at six Level 1 trauma centers over a 1-yr period. Subjects will be randomized to receive FRBC, YRBC (≤ 14 days storage), or ORBC (>14 days storage). StO₂ will be measured using a noninvasive near-infrared spectroscopy probe to determine whether ORBC causes a decrease in StO₂ compared to YRBC and FRBC. Additionally, mediators of the storage lesion, inflammatory parameters, and clinical outcomes will be evaluated and compared between the three groups and correlated with changes in tissue perfusion. This study will be completed in 2 yr.




Efficacy and Safety of Frozen Blood for Transfusion in Trauma Patients, A Multicenter Trial

SJ Underwood, M.S.
I Kremenevskiy, M.D., Ph.D.
MA Schreiber, M.D.
Oregon Health & Science University

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Background

- Blood transfusion commonly utilized therapy
- 30,000,000 units transfused yearly in U.S.
- 15% of blood given to trauma patients
- Average 5 units per patient



Shapiro, et al. J Trauma 2003
Gruenewald, et al. Crit Care Med 2008
Vincent, et al. JAMA 2002

TRAUMA
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Transfusions

- Intravascular volume
- Tissue perfusion
- Hemostasis
- Organ failure
- Death

TRAUMA
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Clinical Outcomes

- Transfusion-related acute lung injury
- Infection rates
- Multiple organ failure (MOF)
- Length of stay (LOS)
- Mortality

Garcia, et al. Transfusion 2004
Chen, et al. Arch Surg 2002
Zoller, et al. Am J Surg 1999
Keller, et al. J Trauma 2002

TRAUMA
Distribution Statement A: Approved for public release; distribution is unlimited. Case Number: #AFMS-2011-5890, 18 Jul 2011

Liquid Red Cell Storage

- 1 °C – 6 °C up to 42 days
- Storage lesion
 - Nitric oxide (NO) metabolism and bioactivity
 - 2,3-diphosphoglycerate (DPG)
 - Free hemoglobin
 - Morphology
 - Decreased adenosine triphosphate utilization



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Preliminary Study

- Prospective, observational study
- 47 trauma patients
- 3 groups
 - Control (no transfusion)
 - New blood (< 21 days old)
 - Old blood (> 21 days old)



Kiraly, et al. / Trauma 2008

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Preliminary Study

Hypothesis – Patients who received older blood would achieve less of an increase in StO₂ than patients who received younger blood.



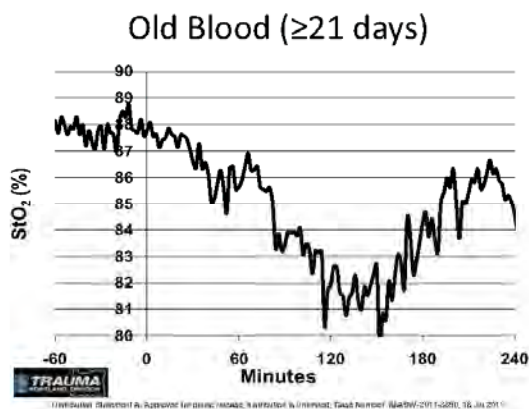
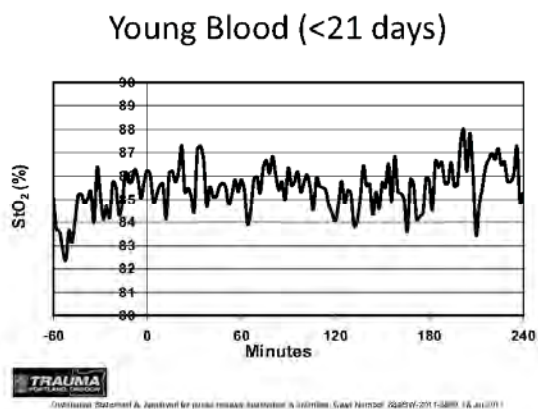
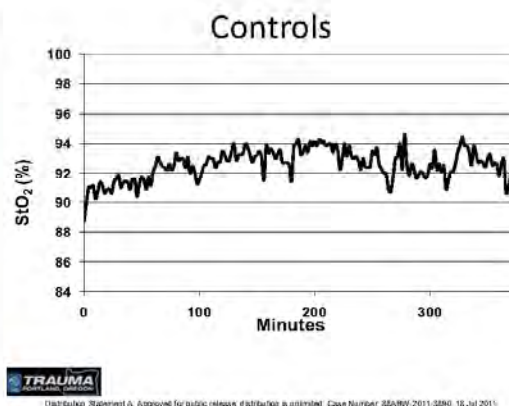
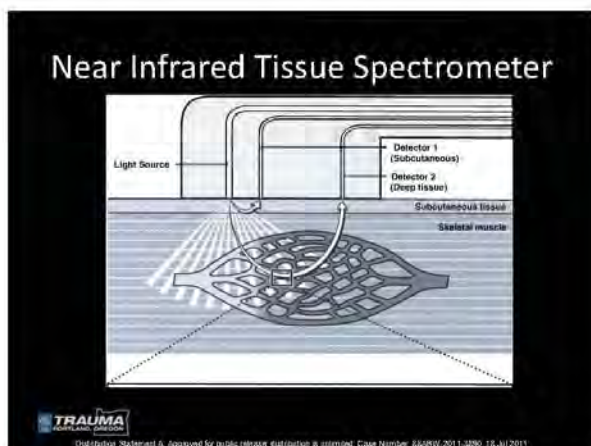
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StO₂ Monitoring

- Probe placed on thenar eminence
- Before, during, and up to 4 h following transfusion
- Controls for 8 h



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Area Under the Curve (AUC)

| | Controls (n = 15) | Old Blood ≥ 21 days (n = 17) | New Blood < 21 days (n = 15) |
|----------------------|----------------------|------------------------------------|------------------------------------|
| Pre-transfusion AUC | 5341 ± 366 | 5205 ± 590 | 5184 ± 563 |
| Transfusion AUC | 5381 ± 333 | 4885 ± 615* | 5200 ± 510 |
| Post-transfusion AUC | NA | 5014 ± 674* | 5210 ± 374 |

*Mean ± standard deviation
p < 0.05



Krialy, et al. / Wound 2009

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Cryopreserved Blood

- Stored at -80 °C
- Up to 10 yr
- Thawing and deglycerolization required
- Decreased metabolic changes
- Inflammatory substances removed



Valeri, et al. Transfusion, 2002

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Hypothesis

We hypothesize that transfusion of cryopreserved blood will be superior to transfusion of older packed red blood cells (PRBCs) with respect to physiologic, biochemical, and clinical parameters and that transfusion of cryopreserved blood will not be inferior to transfusion of younger PRBCs with respect to the same parameters.



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Specific Aims

1. To prospectively determine the influence of cryo- and liquid-preserved PRBC transfusion on vasoconstriction and tissue oxygenation in trauma patients requiring blood transfusion
2. To correlate biochemical changes during blood transfusion with decreases in tissue oxygenation
3. To determine whether transfusion of cryopreserved blood leads to measurable differences in clinical outcomes



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Study Design

- Prospective, randomized clinical trial
- 6 Level 1 trauma centers
 - Oregon Health & Science Univ.
 - Univ. of Texas Health Science Center at Houston
 - Univ. of Texas Health Science Center at San Antonio
 - Univ. of Texas-Southwestern
 - Univ. of California, San Francisco
 - Univ. of Cincinnati



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Eligibility Criteria

Inclusion criteria

- Injury Severity Score > 4
- Blood transfusion
- Consent obtained

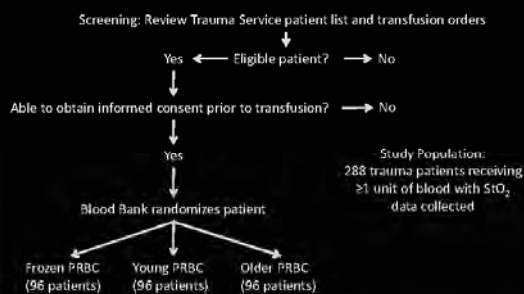
Exclusion criteria

- Emergent transfusion
- Age < 15
- Pregnancy
- Bilateral hand injuries
- Massive transfusion in last 3 mo



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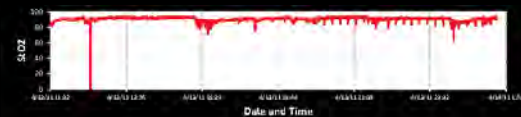
Study Design



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Physiologic Outcomes

- StO₂ measurement
- Begin 1 h pre-transfusion
- End 12 h post-transfusion



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Blood Draws

- Patient
 - Baseline
 - End of unit 1 and 2 (if given)
 - 12 h post-transfusion
- RBC units
 - Units 1 and 2 (if given)



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Biochemical Outcomes

- NO
- 2,3-DPG
- Inflammatory cytokines
- Coagulation tests
 - Thrombelastography
 - Thrombin-antithrombin
 - D-Dimer
 - Activated protein C
 - Tissue plasminogen activator inhibitor
 - Tissue plasminogen activator
 - Plasminogen activator inhibitor-1
 - Tissue factor



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Clinical Outcomes

- Acute respiratory distress syndrome
- MOF
- Sepsis
- Acute renal failure
- Infections
- Intensive Care Unit LOS
- Hospital LOS



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Current Status

- Current Institutional Review Board approvals
- Sites currently enrolling
- Patients randomized



Distribution: Statement A. Approved for public release; distribution is unlimited. Case Number: 65ABW-2011-2090, 1 & 2 Jul 2011

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6143




Distribution Statement A: Approved for public release; distribution is unlimited. Case Number: AABW-2011-2896; 1 & 2 Jul 2011

Women's Health and Illness Behaviors in the Deployed Setting

59 CSPG/SGVUS

Lt Col Candy Wilson

Military women are regularly deployed to austere settings for war and humanitarian missions. The deployed population consists of 10% women. Women's sex-specific health care needs pose a special challenge for women and health care providers in an austere or ship setting where anonymity cannot be guaranteed, self-care supplies are limited, and health care professionals' lack confidence to care for private gynecological concerns. The purpose of this study was to gain a better understanding of the illness behaviors of deployed military women in regards to their genitourinary (GU) health. Ethnography was used to explore and analyze the data because the military has been described as its own culture. The sample consisted of 43 military women from the US Army, Air Force, and Navy who were either deployed or had been deployed within the past year. The researchers uncovered three themes, which included (1) The Sphere of Control, (2) The Dynamics of Trust, and (3) Life in a Deployed Setting. This study is significant to nursing research because it exposes the influence of culture on GU symptom management. Recommendations from this investigation include: (1) a need for better incremental, pre deployment and in theater education for women and medics; (2) informing leaders about the need to ensure the supply of self-care treatments and women's feminine hygiene products are available; and (3) promoting the role of family support stateside as a resource for information, supplies, and emotional support. This study was funded by the TriService Nursing Research Program (N08-P03).



*Let Me Tell You Sister:
Seeking Women's Health Care in
Deployed Settings*

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Women's Health Nurse Practitioner

Disclaimer

- The views and opinions of this presentation are of the author and do not represent the position of the United States Air Force, Department of Defense, or the United States government.
- The author reports no conflicts of interest.

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- This study was funded by the TriService Nursing Research Program (TSNRP), N08-P03.

Purpose of Study

- The purpose of this study was to gain a better understanding of the illness behaviors of military women in regards to their genitourinary (GU) health during their deployment.
- Illness behavior is the perception of bodily changes and interpretation of the symptoms as illness or variations of wellness (Mechanic, 1986; McHugh & Vallis, 1986).

Background

- Military women
 - Make up 10% of the deployed population
 - Work in non-traditional roles that have few female peers and mentors
 - Forward deployed with limited or no gynecologic provider
 - Mostly child-bearing age

Previous Work

- Wilson (2006) conducted secondary analysis of data gathered from previous study
 - 497 military women
 - Self-treated for symptoms less while deployed
 - Sought care more in the most austere conditions
 - When choosing to seek health care:
 - Women living on a ship experienced greater embarrassment
 - Women living in tent experienced more job constraints

Design and Methods

- Ethnography was used to explore and analyze the data
 - Ethnography has anthropological roots that uncover cultural norms
 - The military is described as a unique culture
 - Illness behaviors also can include the validation from others about the symptoms perceived

Data Gathering

- Unstructured interviews were transcribed and coded
 - Interviews lasted approximately 45 minutes at a location that was mutually convenient and private
 - PI and mentor coded transcripts
- Observations were documented with researchers' field notes
- Deployed researcher's diary

Sampling and Recruitment

- A purposive sample of military women were sought for their deployed experiences
- Women from all branches, rank, ethnicity, and marital status
- Two-phased recruitment
 - Flyer advertisement
 - Snowball sampling

Inclusion/Exclusion Criteria

- Inclusion criteria:
 - Any female military member 18 years and older.
 - Been deployed less than one year ago or currently deployed.
 - Managed GU symptoms while deployed
 - Did not have to be diagnosed by a health care provider
 - Symptoms were typically related to UTI or vaginitis /vaginosis
- Exclusion criteria:
 - Deployed greater than one year ago

Demographics

| Demographic | N = 43 women (Withdrawal = 1) | |
|--------------------------|--|--|
| Age | Range 20-49 (mean 30, median 27) | |
| Rank | Junior enlisted = 7 NCO = 22 Senior NCO = 3 | CGO = 5 FGO = 3 Missing = 2 |
| Race/Ethnicity | White = 19 Black = 14 | Hispanic = 5 Other = 5 |
| Marital Status | Never married = 9 Significant other = 2 Married 25 | Divorced = 5 Widowed = 1 Missing = 1 |
| Number of Children | Range 0 – 5 (mean = 1, median = 1, missing = 4) | |
| Number of times deployed | Range 1-5 (mean = 2, median = 1, missing = 4) | |

Findings

- Three themes were uncovered:
 - Life in the Deployed Setting
 - The Sphere of Control
 - The Dynamics of Trust

Life in the Deployed Setting

- Laundry
- Limited hygiene supplies or OTC medications at the exchange
- Job requirements
- Toilet Facilities
 - *It's filthy. There's just nasty trash thrown everywhere. The sinks are covered in God knows what. People would blow their nose in the sink.*

Life in the Deployed Setting

- Uniforms
- Weather
- Showers
 - *You just went in and took your 3 minute combat shower and when it was winter time the water was freezing and in the summer time, the water is burning. You never really felt like you got clean over there because the second you get out of the shower, you're sweating again.*

Sphere of Control



Sphere of Control

- Women's ability to control the environment in which they were assigned.
- Creative management to maintain control was a priority in their daily activities.
- Control over genitourinary symptoms was believed to be important in order to preserve future fertility and this control was not to be taken for granted

Sphere of Control

- Menstruation management
 - *"...you're with a bunch of guys and you're out on a mission for like eight hours and I can pee in a bottle like this guy, but I can't change a tampon".*
- Internet ordering
 - *"She just told us, woman to woman, [about Internet ordering]. She just gave us the 411".*

Dynamics of Trust

- Trust in Self
 - Appraisal of symptoms
 - Know when to self-treat
 - Know when to seek medical care
 - *"[The medications] cleared up my infections for maybe a month. I don't even know if that long. But it came back, but by that time, I was just kind of like...whatever. I can take more, [or I can take] pro-biotic yogurt. I mean I just kind of started looking for things on my own."*

Dynamics of Trust

- Trust in Family
 - Information
 - *"And if [my grandmother] didn't know about it, she'd look it up while I was on the phone".*
 - Supplies
 - *"So he can go out and know he's taking care of me by getting these things together...so he can participate in [the deployment]"*
 - Support
 - *"Your family back home is the biggest thing here. And I don't think they realize that, but they really are like the biggest help".*

Dynamics of Trust

- Trust in providers
 - Expertise
 - *"He asked me what I thought it was...well, heh! I guess I am a doctor"*
 - Resources

Dynamics of Trust

- Trust in System
 - Have supplies to appropriately diagnose and treat symptoms
 - Prepare women for deployment
 - *"More briefings, I guess...some kind of encouragement for girls to talk".*

Discussion



Discussion

- The deployed setting is unpredictable
- The support of others is important to overcome obstacles and limitations
- The role of the family cannot be emphasized enough

Limitations

- Not all interviews were collected in theater
- No Marine women were included in the study

Recommendations

- Prepare women before deployment
 - If they have a gynecologic history to bring supplies
 - Internet ordering
 - Bring hygiene supplies
- Tell women to prepare the family
 - Include the family during the predeployment preparation, especially female family members or husband

Future Research

- Study in progress to interview medics about their perception of women's illness behaviors
- Study in progress to evaluate the use of a Expedient GU Self-diagnosis kit
- Mentor program (similar to a sponsor program)
- Website specific for deployed women to ask about medical care, available to the family

Thank You



